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JULY 1975

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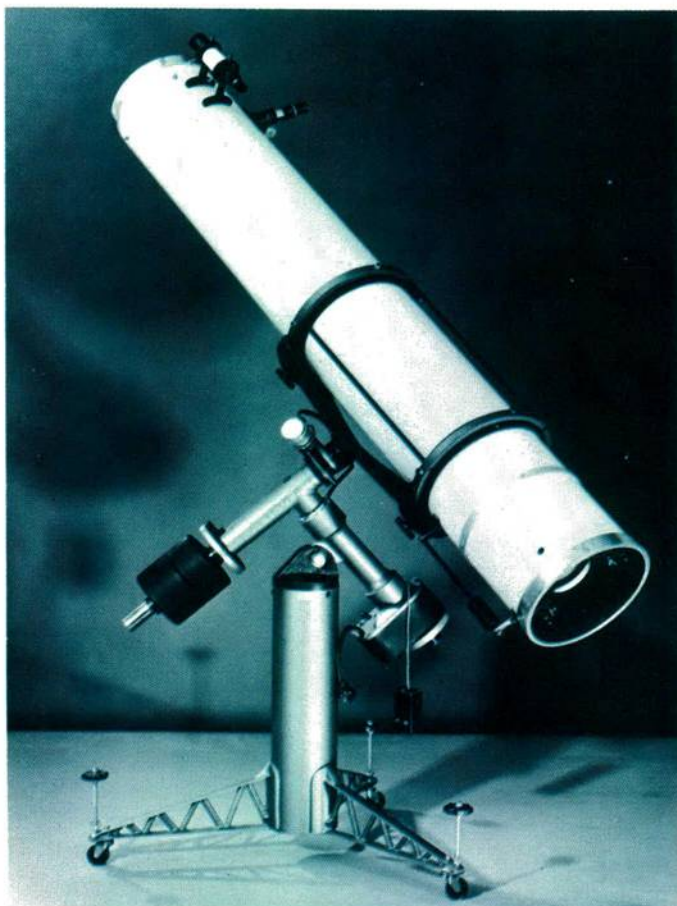
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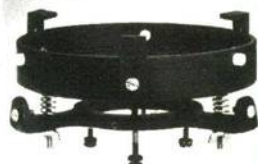
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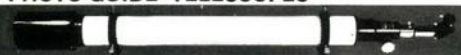


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PUBLISHER'S MEMO

The Good News

What a dizzying time it has been!

For openers, not long ago we concluded an extremely successful subscription building direct mail campaign. With almost 45,000 subscribers across the United States, ASTRONOMY has not yet reached its peak — but it certainly is becoming well-known. Case in point: Carl Sagan was a guest on "The Tonight Show" hosted by Johnny Carson in late April. During the course of their discussion Johnny Carson, an avid astronomy enthusiast, mentioned ASTRONOMY magazine. Thanks very much, Mr. Carson; we're pleased to know you read ASTRONOMY.

Moving on, ASTRONOMY has appointed advertising sales organizations in the east and west. Headquartered in Los Angeles with additional offices in San Francisco and Dallas, J. E. Publishers' Representative Co. will handle ASTRONOMY advertising sales throughout the western U.S. Daniel S. Lipner Publishers' Representative Co. in Westport, Conn. will cover the east coast from Maine to Florida.

Activity centers on editorial matters as this memo is being written. We are enlarging our Milwaukee editorial staff so we may bring you an ever increasingly excellent ASTRONOMY magazine. New editorial arrivals will be announced next issue.

By the way, we've heard an interesting rumor we'd like to share with you. According to "Mr. Grapevine", someone is thinking seriously about publishing an in-depth reference book on astrophotography. According to our source, this book will be a real winner spanning the full gamut of celestial photography, introducing the beginner, equipment, techniques, film, darkroom procedures, and fairly advanced and sophisticated forms of astrophotography. "Mr. Grapevine" also said that the book will be a visual knockout: It will be about 350 to 400 pages in length, printed in full color throughout on high quality, 60 pound gloss enamel paper. Highest quality, gold embossed hardcover binding would be used to make the 8-1/2" x 11-1/2" volume durable, lasting and beautiful. Our source says the book may be offered in limited collectors' editions, hard-bound in leather, in the artful style of the no-longer-practiced bookbinder's tradition.

"Mr. Grapevine" says the astro-

photography book would cost between \$25 and \$35, with the collectors' leather bound edition running appropriately higher.

Frankly, I think the book is an excellent idea. And I'm sure our source would like to have your thoughts on the matter too. So why not write me a letter with your pros and cons on the book and I'll see that he gets your comments.

The Not-So-Good News

With great dismay, I must report a bit of a setback on the eight photographs we want to offer ASTRONOMY readers. After two Publisher's Memos (February and April issues) calling for potential buyers, Kitt Peak National Observatory has decided they would prefer to publish and sell the sets of photographs themselves — which means ASTRONOMY will have to set aside the offer at least for a while. We'll keep working on it though — they may change their minds again. If you'd like to tell someone how disappointed you are that the photo sets will not be available from ASTRONOMY, send a letter to Mr. David Moore, Information Officer, Kitt Peak National Observatory, P.O. Box 26732, Tucson, Ariz. 85726.

The "There's-Still-Hope" News

July 17, 1975 marks an important anniversary for us. That day, two years ago, a high speed web press in Pewaukee, Wisc. gave birth to the first copies of The World's Most Beautiful Astronomy Magazine. Time passes swiftly.

Dynamic, ever-changing events chronolog our infancy making ASTRONOMY's first 24 issues blurr kaleidoscopically.

One final note before I sign off this month. Since ASTRONOMY's first issue in August 1973, the magazine's printing and paper costs alone have increased 83 percent! Many magazines tend to juggle various figures and percentages in order to arrive at such "shock value" figures, and because of this I want you to understand exactly what ASTRONOMY's 83 percent printing/paper increase means.

First, let me stress that this figure represents only printing and paper. It does not include typesetting, separations, or any other production or distribution expenses, salaries, etc. Second, while printing and paper increases have been substantial, our 83 percent figure represents two distinct areas of increase. It includes a) cost increases we planned for in order to give you value/quality improvements in the magazine, and b) inflationary cost increases.

As our readership grew and we reached higher circulation levels, we planned for gradual value and quality

improvements in ASTRONOMY. For example, we knew at 18,000 subscribers we could afford to add 16 more pages, and at 40,000, 16 more. Of our total 83 percent cost increase, 39 percent represents increases that have led to a more valuable, higher quality magazine for you. Specifically, this 39 percent value increase includes the following printing/paper improvements over ASTRONOMY's first issue: a varnished cover to protect the illustrations and give added beauty to the magazine; 32 more pages than issue #1; more than twice as many full color subjects; higher quality paper than we used in the beginning (although it is lighter in weight). These improvements are here to stay — and they resulted directly from your enthusiasm by subscribing to ASTRONOMY or renewing your subscription.

The largest portion of our printing/paper cost increases are an unfortunate and sad reflection of America's current economic plight. In the last two years, ASTRONOMY's basic — per magazine — printing/paper costs have risen by 44 percent. In other words, if we would not have improved the magazine and were still at 48 pages, it would cost 44 percent more to publish 45,000 copies today than it did to publish the same quantity in August 1973.

We have absorbed these increases — and others not related to printing or paper — and we will continue to absorb as many inflationary increases as we can. But is clear that no business wanting to remain in business can afford to absorb these kinds of outrageous inflationary cost increases forever.

It is inevitable, therefore, that at some as yet unspecified time in the future, ASTRONOMY will be compelled to increase its subscription prices. Let me emphasize that we plan no immediate price increase, nor do we plan to increase prices during the remainder of 1975. But if inflation continues as it has, a price increase will be mandatory.

Furthermore, this is not a devious ruse to get you to renew your subscription ahead of time. I feel a personal responsibility to be open and above board with you and merely want to keep you abreast of what's happening here at ASTRONOMY. In the months ahead I'll let you know how inflation fares with your magazine.

Here's hoping next month's Publisher's Memo brings fewer nasties.

Sincerely,



Stephen A. Walther
Publisher

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

July 1975

Vol. 3, No. 7

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Stephen A. Walther

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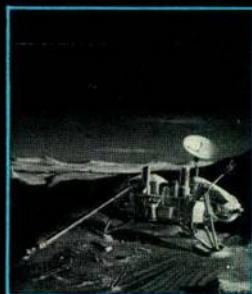
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Martin Marietta Aerospace Artwork by Charles O. Bennett

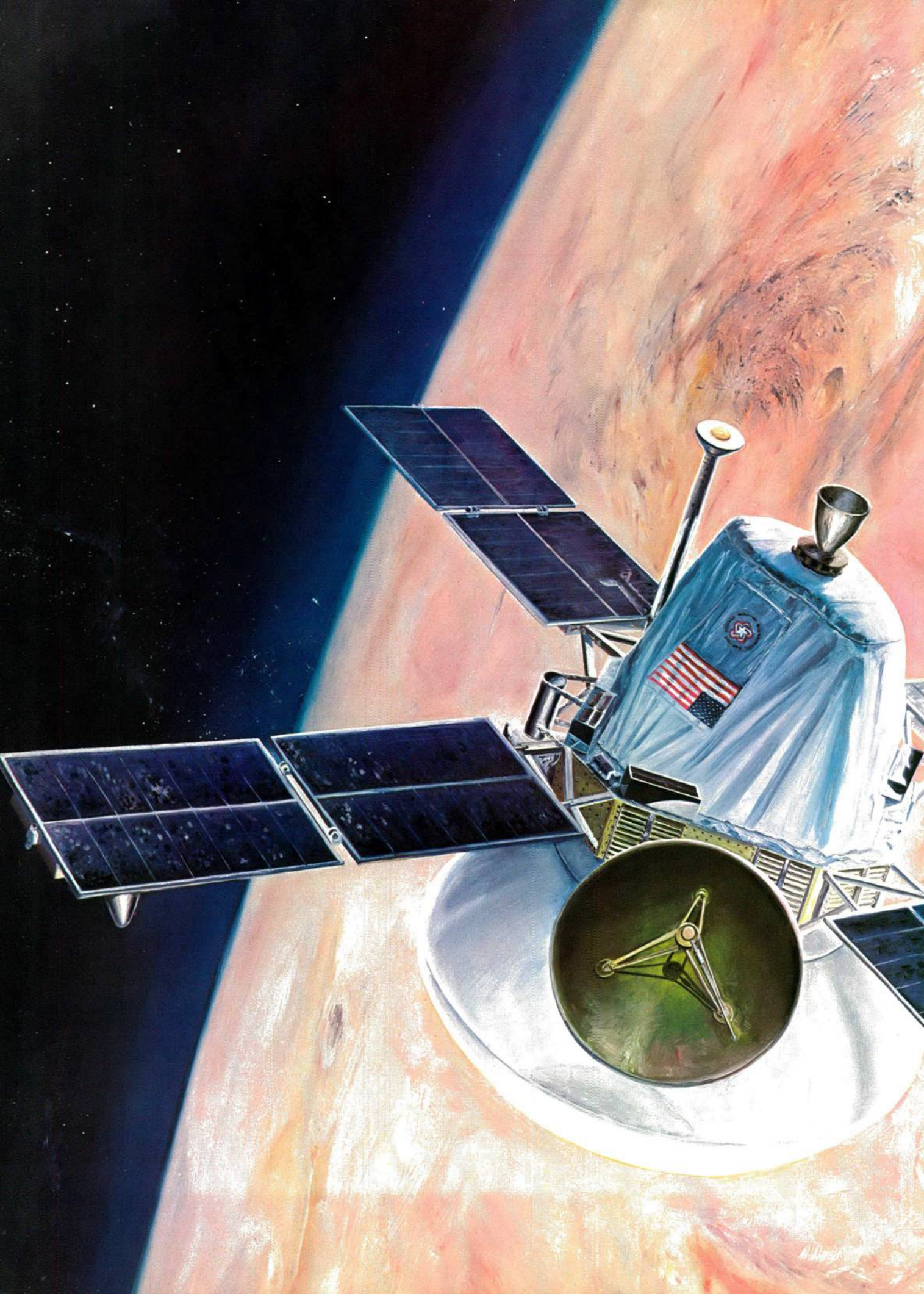
The ungainly looking contraption on this month's cover is an invader from Earth. A pair of these 1,200 pound robots (called Viking landers) will "assault" Mars next July in an ambitious search for extraterrestrial life. The Viking odyssey begins this summer with the launching of two combination orbiter/lander spacecraft from Cape Canaveral. The landers will spend most of the flight "canned" within sterilized capsules that keep out any contaminating Earthly microorganisms. Prior to the mission, the landers themselves will be heat sterilized to reduce the likelihood of contamination on Mars to 10,000 to 1 odds. Once on Mars, each lander's mechanical shovel on the end of an extendible 10 foot boom will scoop up soil samples and feed them into a miniature biochemical laboratory for analysis. This month's lead article explores how the extremely complex Viking mission may answer one of man's oldest questions: Does life exist beyond Earth?

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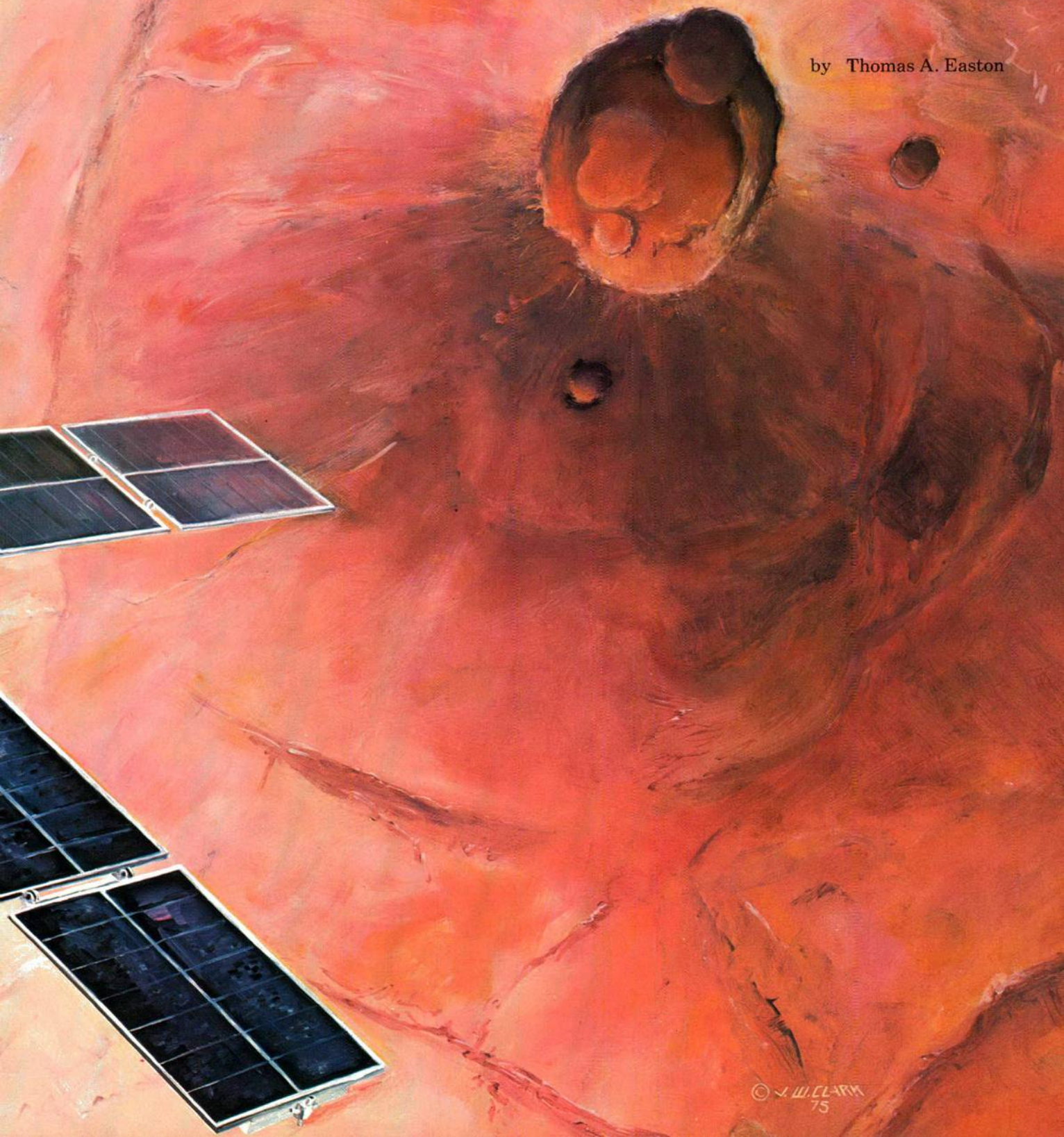
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The Quest for Life on Mars

by Thomas A. Easton



A year from now, sometime in the summer of 1976, two interplanetary robots will set down on Mars to give humanity its first close look at the surface of another planet. They may even tell us whether life on Earth is the only life in the solar system.

Mars is the only planet in our solar system whose surface temperature range overlaps that of Earth, and which may have — or may once have had — enough water to give life a start. True, the Mariner flybys of 1965 and 1969 showed Mars to be a cratered billiard ball, nearly as pock-marked and seemingly lifeless as the moon. But the Martian

landscape as revealed by the orbiting Mariner 9 (displayed in ASTRONOMY in many previous issues) does show signs of softening this image. Some of the meteoric hammer-blows of the distant past have been as thoroughly erased as those of Earth. Erosion by wind and perhaps water has worn down the hills and filled the hollows — at least a little.

The Martian atmosphere is now known to consist largely of carbon dioxide (CO₂), with small amounts of carbon monoxide (CO) and oxygen. It even contains a little water vapor, though less than two percent of the amount contained in Earth's atmosphere. (See Astro-News for an article about recent research on the Martian atmosphere.) The surface temperature of Mars ranges from a low of about 185 degrees below zero Fahrenheit in the polar caps to a high of about 85 degrees above zero for a few hours a day in equatorial regions during the Martian summer. The atmospheric pressure averages about 5/1000 that of Earth.

Mars is, therefore, cold, dry and inhospitable to Earth life. It does not have enough air (of any

Caption for page 6

The search for life on Mars will be conducted by two Viking robot spacecraft — the most complex vehicles ever to explore another planet. Here Viking 1 is seen about 10,000 miles above the giant volcano Olympus Mons, only moments before the clam shaped lander separates for its three hour descent to the planet's surface. The powerful single engine propulsion system, used to place the craft in a precise 24.6 hour orbit of Mars, has its large fuel tanks shrouded in a protective covering. Viking is large for an unmanned craft — 32 feet from tip to tip of its solar panels.

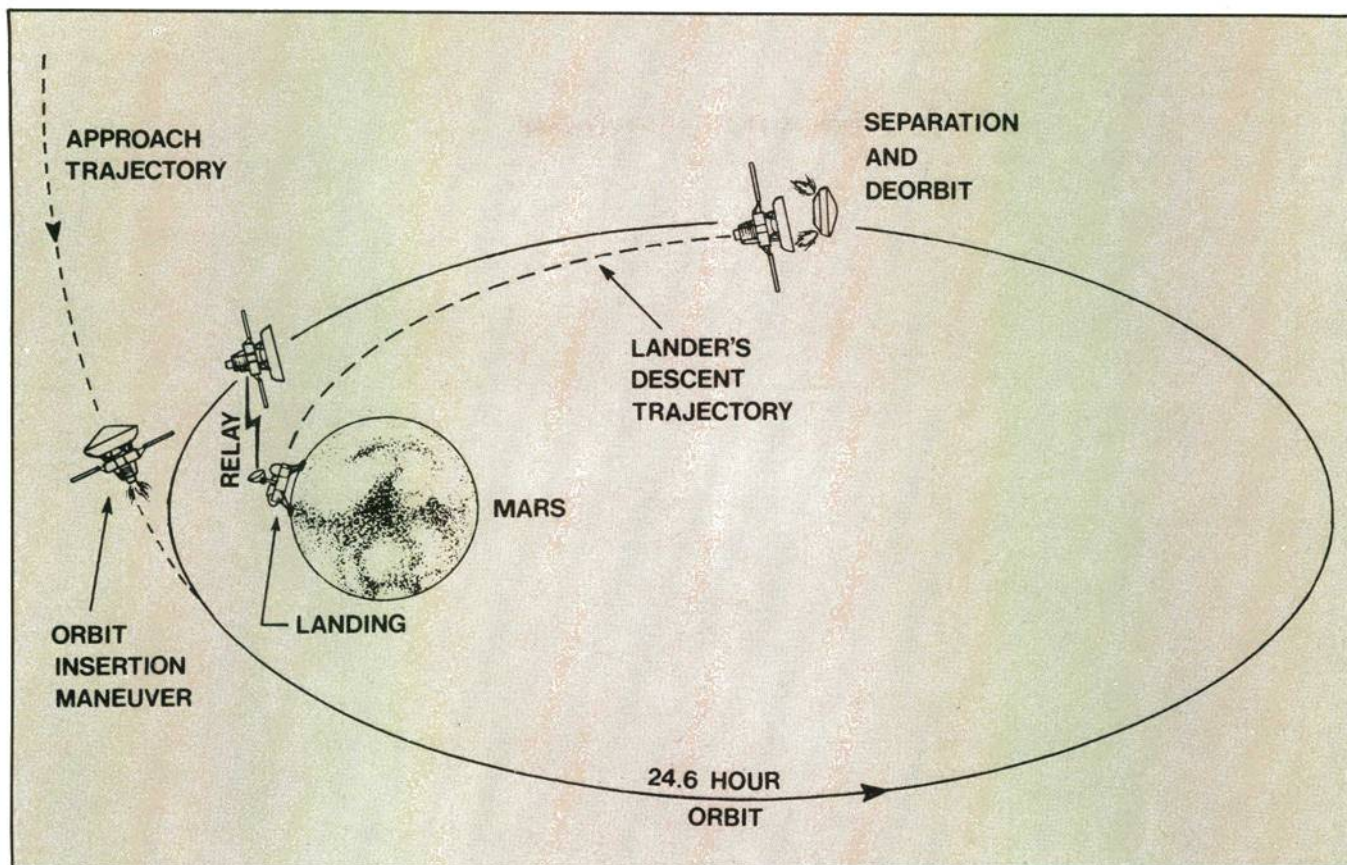
Artwork by John W. Clark



A major Martian dust storm whips around the base of Olympus Mons, one of four towering volcanos in Mars' Tharsis region. Shortly after Mariner 9 arrived at the red planet in late 1971, the summits of Olympus Mons and its companions were the first

surface features to poke above a subsiding global dust storm. From dust cloud structures observed near these volcanos, Mariner 9 researchers calculated a wind speed of 120 m.p.h. (almost 1/3 the velocity of sound on Mars).

Artwork by Adolf Schaller



The looping path of the Viking orbiter will bring the craft to within 800 miles of the planet's surface, close enough to photograph objects a few hundred feet across. The orbit will be syn-

chronous to Mars' rotation; that is, at its low point the orbiter will always swing over the same region of Mars — the lander's position — if all goes well.

kind), water, oxygen, or heat by our standards. But our standards are not the only possible ones. Even on Earth, forms of life exist which can survive and grow outside the conditions we consider normal. Bacteria and algae can thrive at temperatures ranging from 10 to 200 degrees Fahrenheit, and they can *survive* even greater extremes. Fish can withstand the thousand-atmosphere pressures of the ocean trenches, and plants the tenuous airs of mountain tops. Many organisms can survive almost complete desiccation, though they all need water for growth and reproduction. And a few bacteria have proven able to survive simulated Martian conditions. If water and heat were available only occasionally, their kind could thrive on Mars.

The present Martian conditions are severe, but the past may have been different. Mars' polar caps are believed to be thousands of feet thick in spots and may contain cubic miles of water beneath a surface of frozen carbon dioxide — water that may once have flowed freely across the planet's surface. The pits and hollows shown in some Mariner 9 photos could have formed from the thawing of vast quantities of underground ice, which suggests that more water lies frozen elsewhere. The photo on page 15 shows what appears to be the remains of long-gone rivers whose waters are now locked in the icecaps

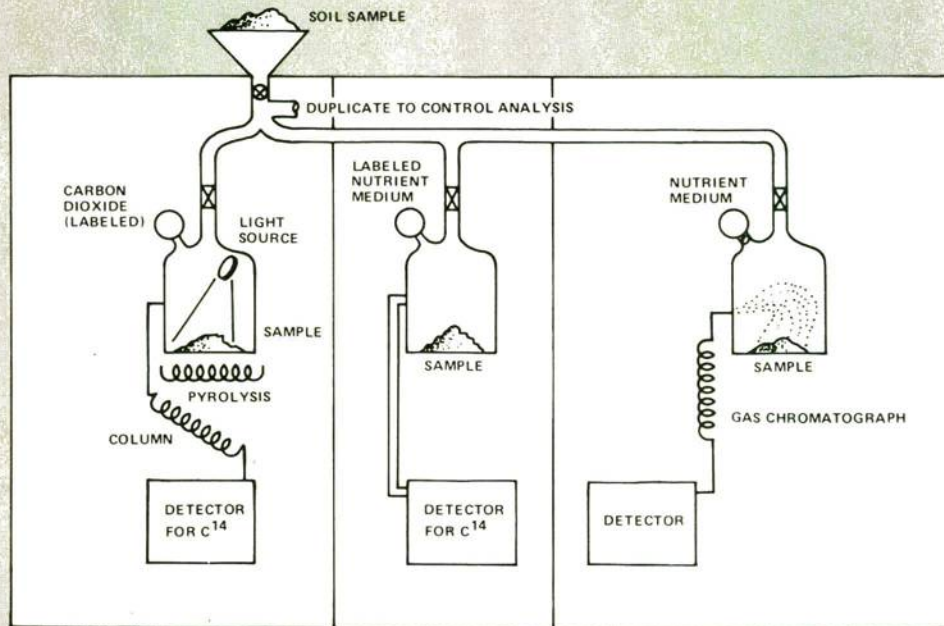
and frozen beneath the ground. These channels are so strikingly similar to those found on Earth that they are considered by many scientists to be convincing evidence for once-free water on Mars.

The evidence is, in fact, striking enough that we can assume — at least for the purposes of this discussion — that Mars was a far more congenial, warm and wet place once upon a time. And that

Previous Mars Missions

1965: Mariner 4	A photographic flyby of the planet at an altitude of 6,118 miles — 18 usable photos.
1969: Mariners 6 and 7	Photographic flyby at an altitude of 2,200 miles — 201 usable photos.
1971-72: Mariner 9	The spacecraft orbited the planet 698 times in 349 days, far outlasting its design lifespan. Cameras on board took 7,232 photos mapping the entire surface of the planet.

The Viking Life Detection Experiments



The three experiments designed to test specifically for the presence of life on Mars are the *pyrolytic release*, *gas exchange*, and *label release* experiments. Each will use small amounts of the soil collected by the sampling boom, and though they differ in their techniques, they are alike in that each depends upon the way all life (that we know of or think likely) uses carbon oxides.

In the pyrolytic release experiment, the soil sample will be incubated at about 45 degrees Fahrenheit under light (generated by a lamp designed to mimic Martian sunlight) and with the normal Martian atmosphere replaced by a mixture of 95 percent radioactive carbon dioxide and five percent radioactive carbon monoxide. (The radioactivity comes from the use of the carbon 14 isotope of carbon instead of the more common carbon 12 isotope). The course of the experiment may be varied upon command from Earth either by turning off the light or by adding water vapor.

After five days of incubation, the sample will be heated to 1,150 degrees Fahrenheit; the gases given off will be swept by a helium purge into a vapor trap, which will catch and hold any and all organic molecules. The gases which are not trapped will pass through a detector for radioactive carbon, but the acid test for life will be still to come. A final purge of the system with helium will remove all gases, and the vapor trap will then be heated to 1,290 degrees Fahrenheit to turn the carbon in the organic molecules it has trapped into carbon dioxide. This gas will also pass through the detector, and if the radioactivity count is high at this point, it will mean that the labeled carbon carbon dioxide (CO₂) and/or carbon monoxide (CO) have presumably been incorporated into living cells. This is the only way in which the original labeled CO₂ and CO can be caught by the vapor trap for the later release — but nevertheless, the result will have to be checked. This will be accomplished by heating a second soil sample before incubation (to sterilize it) and then repeating the experiment. A negative result at this point will be strong evidence indeed for life.

In the gas exchange experiment, the soil sample will be incubated for seven days under an atmosphere of helium, krypton and carbon dioxide, together with either added water vapor or added water and nutrients (amino acids, vitamins, etc.). The two options are intended to follow each other on the same sample, and under both options fractions of the atmosphere surrounding the sample will be periodically drawn off and run through a gas chromatograph for identification. Any changes in the composition of this atmosphere will indicate the presence of metabolic activity — and again, a negative check by preheating a soil sample and repeating the experiment will confirm that indication.

In the label release experiment, a soil sample will be incubated for 11 days under normal Martian atmosphere and with a dilute solution of nutrients (organic salts and acids) labeled with radioactive carbon. The atmosphere surrounding the sample will then be monitored continuously for any release of radioactive carbon dioxide (or other gas). As in the gas exchange experiment, a positive result will mean the presence of metabolizing cells, and the negative check will confirm it. 

"once upon a time" is all we need to predict the existence of life on Mars *now*.

Like Earth, Mars was formed from the dust and gas of the solar nebula, and its first atmosphere — like Earth's original atmosphere — must also have included all those substances that gave rise to life on our world. Among them would have been cyanide, hydrogen, sulfide, carbon dioxide, carbon monoxide, water, methane, ammonia, formaldehyde, formic acid, methanol, ethanol, and many others which were known to be in the primordial solar nebula because these same substances have been observed in interstellar clouds by radio astronomers.

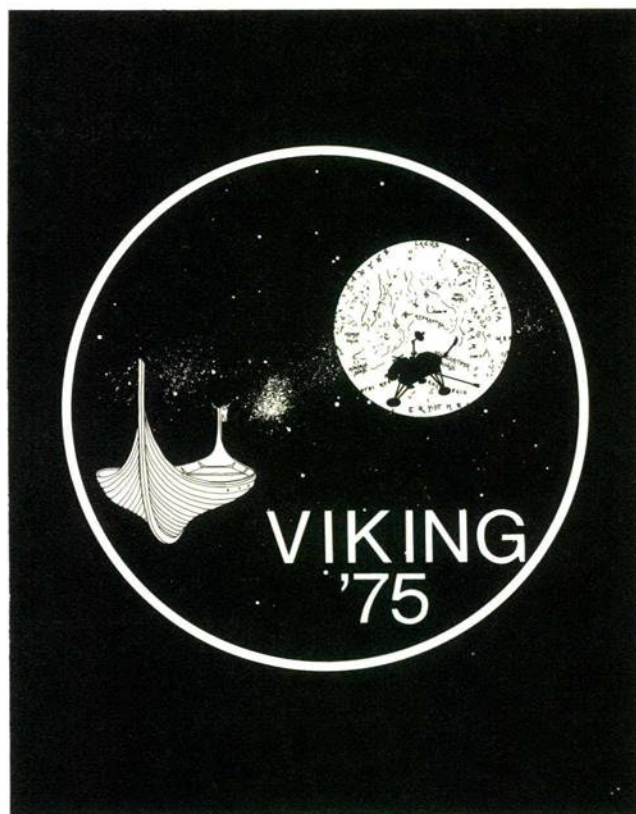
Once Mars was formed, solar radiation, lighting and the internal heat of the planet would have driven chemical reactions to turn these substances into precursors of amino acids (the building blocks of proteins) and the other molecules characteristic of life. We have found that even on the presently airless moon, there remain the signs of these reactions in the form of organic compounds. The lunar compounds, however, never passed the precursor stage. For that, water is needed — and if water is added to lunar soil, true amino acids can be found.

Thus Mars, with its suspected once-ample supply of liquid water, must have gone on to amino acids and further. In other words, Mars must once have had a primeval soup much like the one in which Earth's life arose, and any life that formed on Mars must have begun as similar to Earthly life.



Lunar and Planetary Laboratory Photograph

Photographs such as this one taken with a 61 inch telescope represent the best imaging of Mars available from Earth. Next year the Viking landers should return photographs of the soil of this intriguing world — a remarkable testimony to a decade of planetary exploration.



Artwork by Jon Lomberg

This Viking emblem was presented to NASA several years ago when the space agency was considering official symbols for the mission. Later it was decided to restrict the emblem competition to high school students. The Viking program is the most complex unmanned exploration of space ever undertaken.

The alternative chemistries — ones involving methane, ammonia, silicon, etc. — are not really possible; the cosmic abundances of the alternate elements are not sufficient, and the chemistries of their compounds are not as fertile. Only carbon-oxygen-hydrogen life is feasible. The chemistry of the compounds of these elements make life inevitable wherever there is liquid water.

Experiments have shown that if an aqueous mixture of amino acids is evaporated (as on a volcanically heated rock) and then heated to about the boiling point of water, the amino acids link up into a proteinlike substance called *proteinoid*. If this proteinoid is then suddenly put into solution — as by a wave washing over the rock — tiny bacteria sized spheres will be formed; these spheres will grow and reproduce, much like true, living cells. They are thought to be, in fact, the very things from which life began — for they have the potential of evolution and are readily formed under conditions which must have existed on primordial Earth — as well as on primordial Mars.

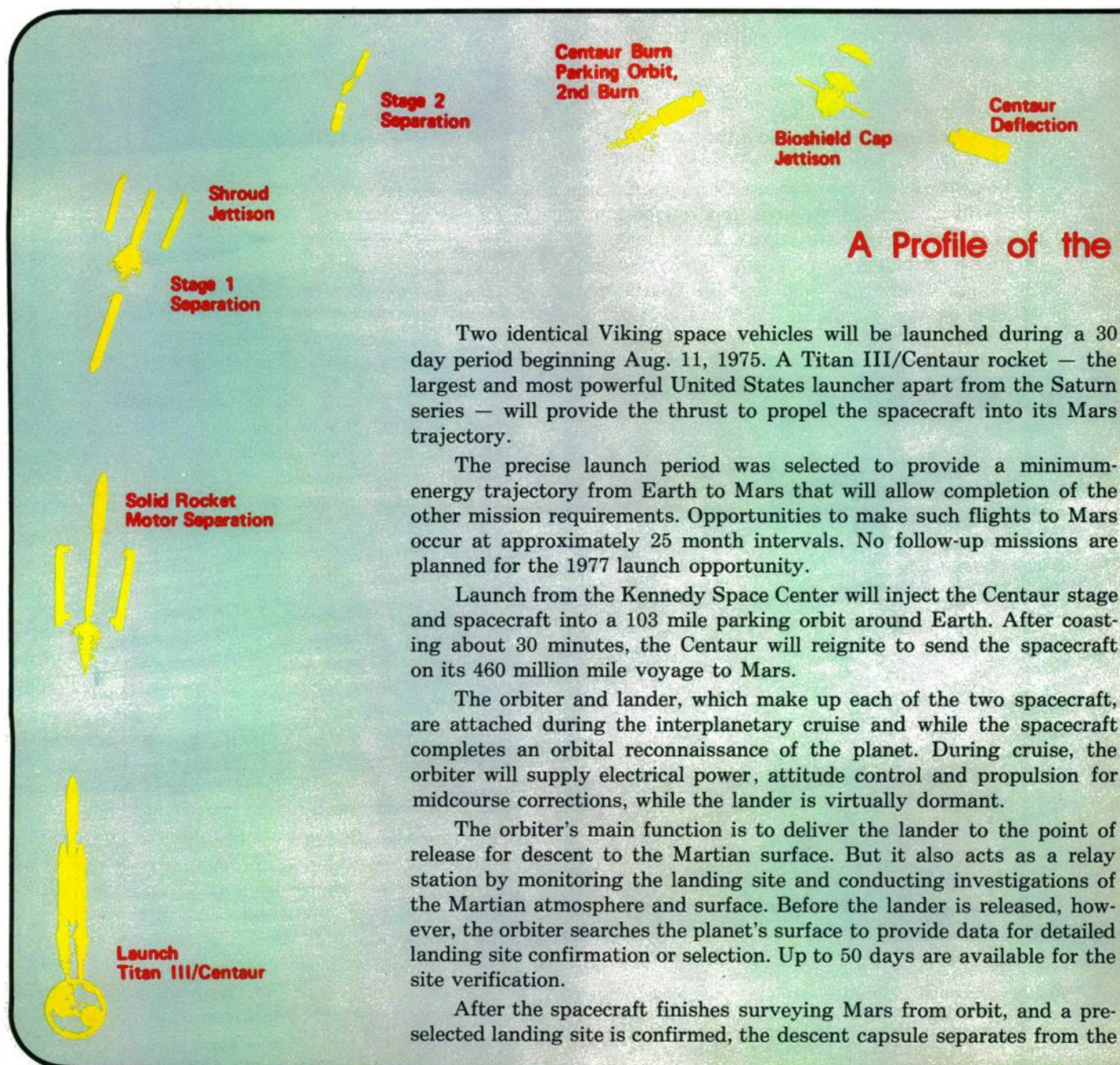
It is quite clear, however, that the further evolution of life could not have followed the same course on Mars as on Earth for long. Given the chemistry of life, some parallels are certain — but they would have had to end as soon as Mars

began to cool off and dry up, as soon as it began to lose its originally hospitable character. The process could have begun very early in Mars' history, but when we consider that the earliest fossils known on Earth date to within two billion years of this planet's formation, and that these fossils are themselves the products of eons of evolution, it seems reasonable to think that even on Mars life would have had time to get well on its way. It might have needed only a few hundred million years.

Mars has probably been in something like its present state for most of its existence. The nature of its orbit around the sun may allow it an occasional few millennia of relative warmth, and its climate may have varied from other causes. But

the number and distribution of the Martian craters suggest a long lasting and static environment. The departure from any congruence with Earth's biological history must have occurred early. Martian life at that time must have included nothing more complex than bacteria, fungi, some simple plants, and perhaps some arthropodlike animals (similar to insects, crabs and sand fleas).

These organisms would have had a vast adaptive potential. Their counterparts on the friendlier Earth have expanded to cover the planet's surface and learned to survive its harshest corners — corners which in some respects are harsher than we know must exist on Mars. On the early Mars, they would have proliferated in much the same way — occupying both the warmest, wettest spots and the



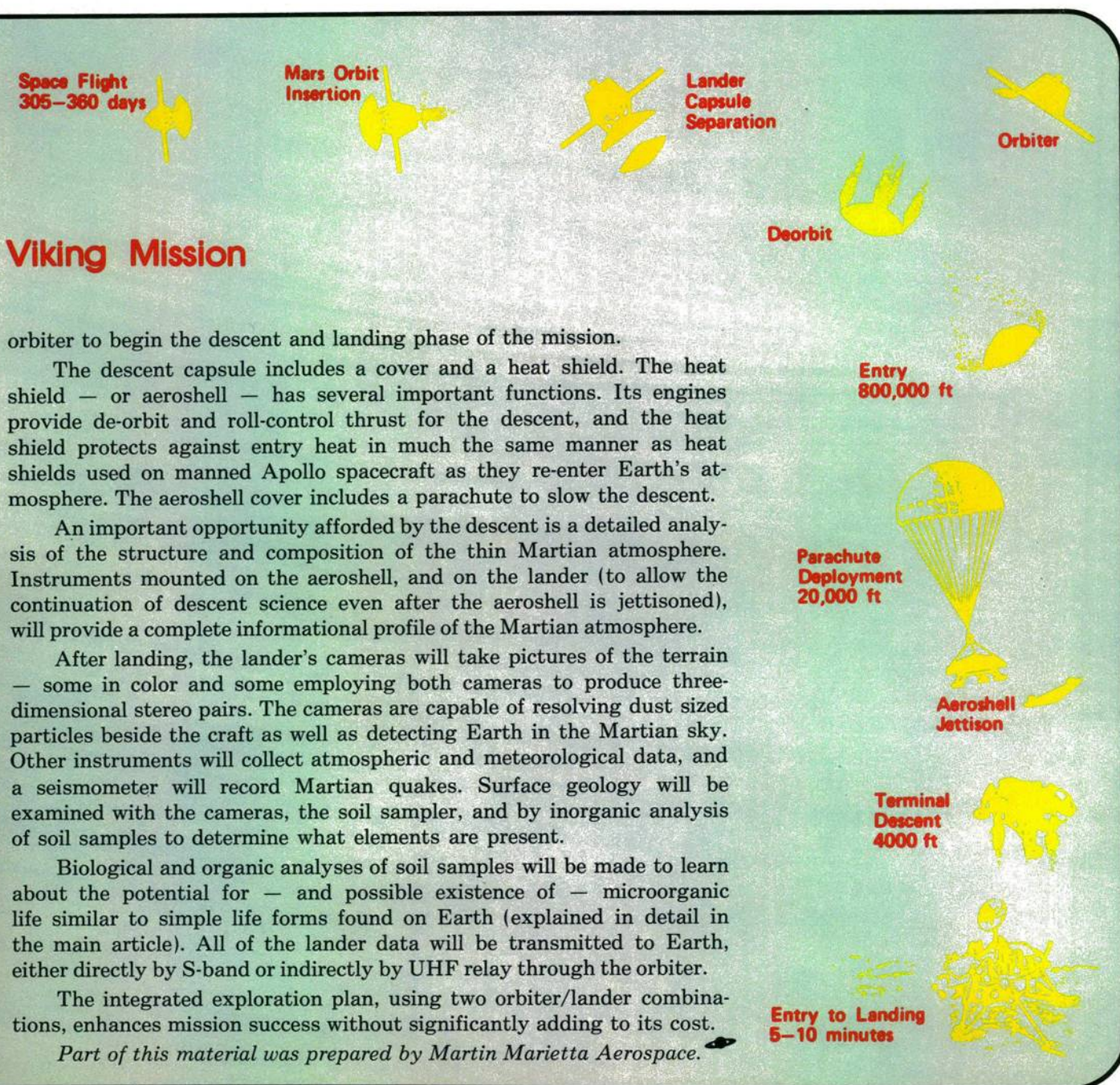
coldest, driest ones. And as Mars grew more hostile, the organisms already adapted to harsh conditions would have spread out, adapted further, and taken over the rest of the planet (though they would have continued to favor the choicest spots). If life ever existed on Mars — and we have every reason to think it must have — it therefore must still be there.

At best, then, the robot explorers from Earth may actually photograph sand crabs and lichens, or perhaps some higher evolutionary development of an insect. They might even find intelligent beings. But they are far more likely to find nothing but single celled bacteria. The Martian environment is implacably hostile to life, and we are probably on our safest ground if we assume that while it allowed

life to begin, it allowed little more than that.

If we are to imagine the form of life on Mars, we must first realize that it cannot use oxygen; the Martian atmosphere contains no more of this vital gas than might be attributed to the splitting effect of sunlight on CO₂ and water vapor. Oxygen-producing plants are therefore rare at best, and the animals — if they exist at all — do not breathe oxygen. Whatever life there is on Mars must instead use metabolic pathways similar to those most Earthly life abandoned long ago, when the first blue-green algae and green plants began to fill Earth's air with oxygen.

These pathways are represented on Earth today by such organisms as the purple and green sulfur bacteria. Where modern plants use light to turn



orbiter to begin the descent and landing phase of the mission.

The descent capsule includes a cover and a heat shield. The heat shield — or aeroshell — has several important functions. Its engines provide de-orbit and roll-control thrust for the descent, and the heat shield protects against entry heat in much the same manner as heat shields used on manned Apollo spacecraft as they re-enter Earth's atmosphere. The aeroshell cover includes a parachute to slow the descent.

An important opportunity afforded by the descent is a detailed analysis of the structure and composition of the thin Martian atmosphere. Instruments mounted on the aeroshell, and on the lander (to allow the continuation of descent science even after the aeroshell is jettisoned), will provide a complete informational profile of the Martian atmosphere.

After landing, the lander's cameras will take pictures of the terrain — some in color and some employing both cameras to produce three-dimensional stereo pairs. The cameras are capable of resolving dust sized particles beside the craft as well as detecting Earth in the Martian sky. Other instruments will collect atmospheric and meteorological data, and a seismometer will record Martian quakes. Surface geology will be examined with the cameras, the soil sampler, and by inorganic analysis of soil samples to determine what elements are present.

Biological and organic analyses of soil samples will be made to learn about the potential for — and possible existence of — microorganic life similar to simple life forms found on Earth (explained in detail in the main article). All of the lander data will be transmitted to Earth, either directly by S-band or indirectly by UHF relay through the orbiter.

The integrated exploration plan, using two orbiter/lander combinations, enhances mission success without significantly adding to its cost.

Part of this material was prepared by Martin Marietta Aerospace.



CO₂ and water into carbohydrate and oxygen, these bacteria use light to turn CO₂ and hydrogen sulfide into carbohydrate, water, and sulfur. To them, oxygen is a poison. But the carbohydrates they produce can nevertheless fuel an ecology. Numerous other bacteria can use these energy-rich compounds as their own foods, and many can do it without oxygen.

Other possible pathways also exist, including a few that have not been seen on modern Earth. NASA's M. A. Mitz, for example, has pointed out that the carbon monoxide of the Martian atmosphere could react with water to give carbohydrates and carbon dioxide. Constantly replenished by the splitting of CO₂ by sunlight, CO could therefore fuel a Martian ecology (although the small amount of CO in the Martian atmosphere is probably too little to support anything but small numbers of tiny organisms).

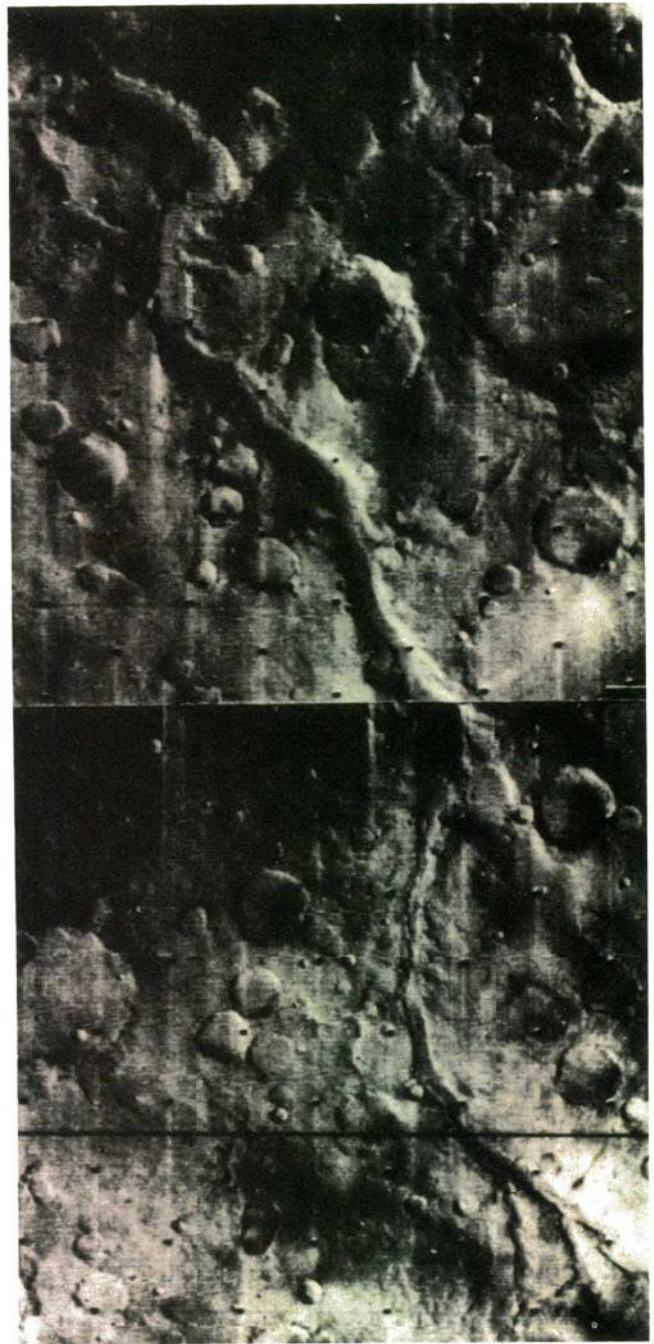
But all the possible metabolisms of carbon based life have one thing in common: They all center around the way in which plants (the food makers) build an oxide of carbon — usually carbon dioxide, but possible carbon monoxide — into carbohydrates, and animals (the food users) release it again. There are no exceptions, and the Viking landers should have little difficulty in detecting whatever Martian life there is to be found.

Viking's success will be aided greatly by the search the orbiters will carry out even before the landers set down. While still in space, they will scan the surface of Mars, mapping the distribution of water vapor and heat, looking for smooth landing sites that are relatively low (and hence under relatively high atmospheric pressure), wet and warm. It is in such spots that Martian life will certainly be found, for there conditions will be most favorable.

Once on the surface, the landers will photograph the Martian terrain, beginning their search for life with their cameras. If there are any living things of much more than microscopic size — or any buildings, ruins or parking lots — to be seen, they will find them. But the Viking cameras will almost surely show us nothing but rock and sand. The detection of life will rest on the landers' ability to capture samples of the Martian soil and examine them far more closely than a camera possibly can.

When the Viking project was first being planned, one of the methods being considered for obtaining soil samples involved shooting out a plastic cable, rather as a snake shoots out its

Dwarfing the Grand Canyon is Vallis Marineris, the great Martian chasm. Up to 50 miles wide and 20,000 feet deep, the rift carves a 3,000 mile gash across the red planet. Along the edge of the main canyon are what appear to be water erosion tributaries. Whether water did in fact create these sinuous features is a subject for debate among planetary scientists. If water ever did flow on Mars, the author believes some form of life would have developed.



NASA Photograph

Sinuous channels etched across Mars' surface, like Vallis Maadim (20 degrees south latitude, 182 degrees west longitude) above, present dramatic evidence that liquid water once flowed on that dry world. Water is the only likely fluid that could have carved the fingerlike tributaries evident in the southern half of this 450 mile long "dry riverbed". The Martian channels resemble dry arroyos that are created by sporadic water flows in Earthly deserts. Planetary scientists remain puzzled about the origin and current condition of Mars' water supply.

tongue. This cable would carry an electrical charge which would make the Martian dust stick to it until scraped off when the cable was retrieved. This idea was abandoned when the first unmanned lunar landings showed that a mechanical scoop could not only do the same job, but test the soil for consistency and carry useful instruments as well. The

Mars Exploration After Viking by Terence Dickinson

Our ability to propel robot explorers to worlds beyond our own has truly made us inheritors of a solar system — moons, planets, asteroids and comets. The unmanned exploration of any of these objects usually comes in five stages: long term scrutiny by Earth based telescopes, quick photographic reconnaissance from flybys or impacting craft, detailed photographic and instrumented studies from orbit, instrumented examination of the surface, and collection of surface material to return to Earth. In the case of the moon, the final stage was largely a manned venture — but that will probably prove to be an exceptional case.

In the exploration of Mars, the Viking mission will mark the execution of all but the last one of these phases. The next step (regardless of the discoveries of Viking) is to return a precious sample of Martian soil to Earth. The Viking findings will likely have some bearing on the speed at which this task is carried out, but it seems inevitable that it will be the next major step in Mars exploration.

The space science board of the National Academy of Sciences had its exobiology panel meeting in August 1974. After their evaluation of Mars' sample-return mission concept, they "strongly endorsed the return of an unsterilized sample from the Martian surface. We consider the return of a surface sample from Mars to be the most important goal of the planetary exploration program," they emphasized.

Equally strong recommendations came from the Future Exploration of Mars Study Panel (also conducted under the auspices of the National Academy of Sciences). The panel of 18 scientists recommended that sample-return be adopted as the keystone of Martian exploration, and that it be incorporated into the NASA baseline plan for solar system exploration over the next 15 years. The panel suggested the period between 1984 and 1990 as an appropriate time for a Mars sample-return mission based on an analysis of current budget trends.

A problem that the committee and others who have studied the sample-return concept wrestled with is the specter of the returning sample container missing its ocean landing target and impacting on rock, possibly releasing the Martian soil to the terrestrial environment with unknown biological effect. Seeing the obvious importance of getting a pristine piece of Mars back to Earth, several NASA scientists have tackled the problem of exactly how such a mission could be accomplished. Two basic mission profiles have evolved from these studies.

The first is the *direct return* mission which envisions a spacecraft either launched by the Space Shuttle or by a Titan III E/Centaur launch vehicle similar to the one that will propel the Vikings to Mars. From a parking orbit around Earth, the spacecraft will thrust to Mars, dispense with any preliminaries and plunge directly at the surface of the red planet. Parachutes and braking rockets will bring the craft to a soft landing. An arm similar to that on the Viking lander would pick up the sample and drop it into a small football sized container which would then be triple sealed in various airtight compartments inside the returning portion of the vehicle. Almost immediately the canister segment would blast from the surface of Mars — a miniature version of the way the Apollo astronauts left the moon. The sample container would go into orbit around Mars — but because of the orbital geometry between Earth and Mars, it would have to remain in orbit about the planet for a year. When the two planets were finally in optimum position, the returning vehicle would fire its rockets sending itself out of Martian orbit on a direct descent to Earth — once again much as the Apollo flights. Slowed by atmospheric braking and parachutes, the precious interplanetary voyager would be collected from an ocean landing or perhaps by a cargo plane that will hook onto its parachute as it descends through the atmosphere. In terms of complexity and cost, the mission would be comparable to a single Viking mission.

The second method that is currently under study for Mars sample-return is called the Mars *orbital return* method. The spacecraft used in this method is very similar to Viking except that both the lander and orbiter have most of their scientific experiments removed, being replaced on the orbiter with larger propellant tanks and thrust system, and on the lander by a self-propelled canister that ejects the samples from the surface of Mars into orbit. Getting to Mars will be by essentially the same launch vehicle and technique as the Viking mission. However, at Mars the landing portion is ejected from the orbiter before that vehicle begins to circle the planet. The lander makes an immediate soft touchdown on Mars and a sample is collected soon afterward. A short time later, the protective sample canister is launched from the lander for rendezvous with the



Viking spacecraft modified
for a 1980s sample-return

orbiter. With the main mission accomplished, the orbiter's propulsion system thrusts it from the orbit of Mars for a return to Earth. Near Earth the orbiter places the sample container into an orbit of our planet. This allows a Space Shuttle or other vehicle to go up and retrieve it rather than taking a chance that the final return will backfire and spread the sample over a portion of the surface of Earth.

Naturally this second and more cautious method is the more expensive and demanding of vehicles and their various components. As yet both methods remain in the design stage with no large amounts of funding assigned. There is at present no pressure to make a decision as to which method will be used.

In view of the Soviets' previous experience in collecting samples from the moon and returning them safely to Earth, it is possible — and indeed some have suggested probable — that the Soviets will be returning soil from Mars to Earth before we do. This was a common view until rather recently; now information from those in touch with Soviet scientists say that recent setbacks in their program put a Mars sample-return a long way in the future.

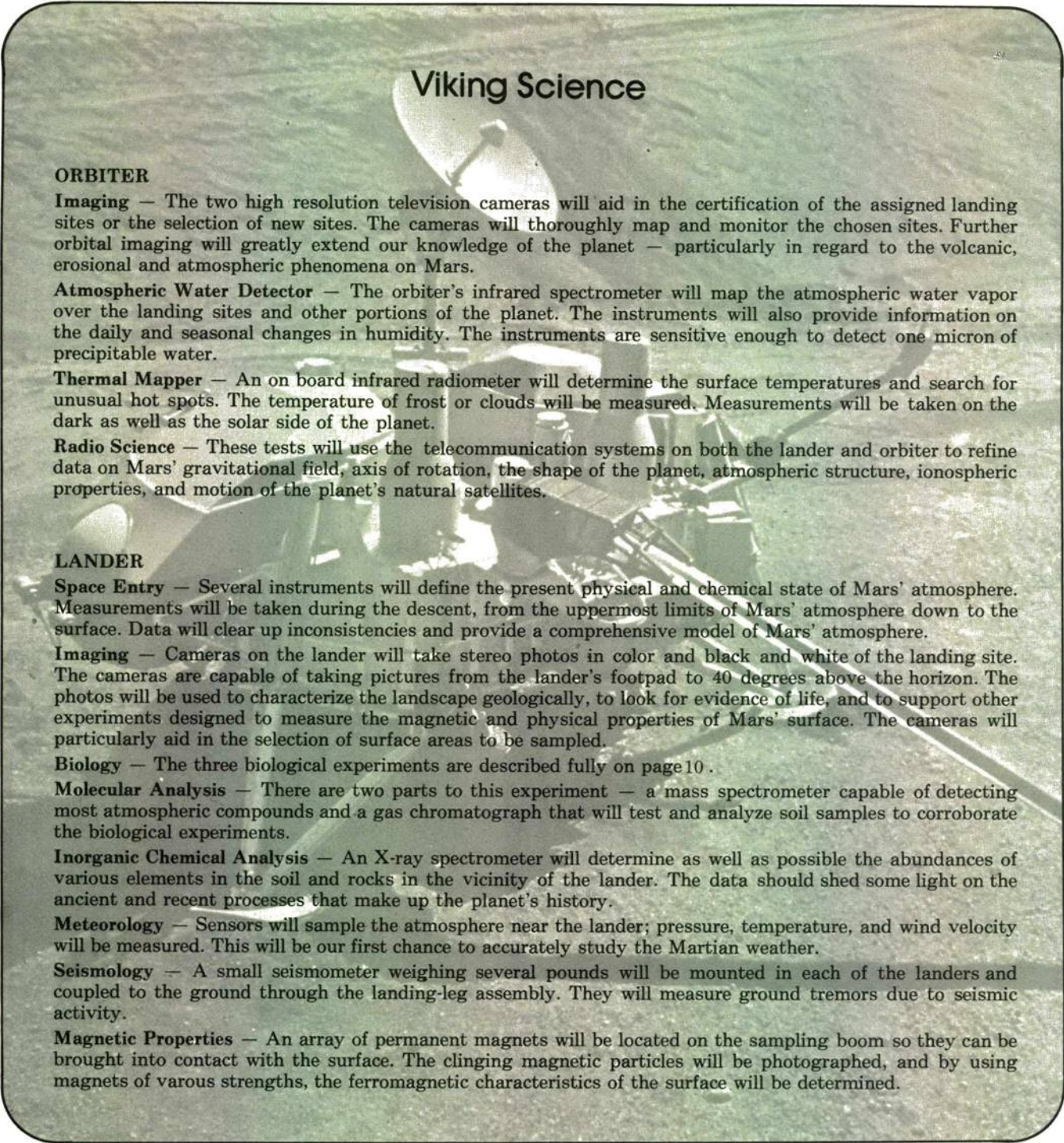
Soviets' experience in automated robot rovers on the moon has also been cited as a "practice run" for a Mars Rover. But there is a fundamental difference between robot roving on the moon and doing the same thing on Mars. Moon rovers called Lunakhods were controlled by an operator at a control console on Earth who, in effect, drove the little eight wheeled vehicle over the lunar surface. The operator experienced a 2.6 second communications delay caused by the 240,000 mile distance to the moon. The delay caused only a few minor problems and did not jeopardize the mission. On Mars the situation is different because the increased distance increases the two-way transmission time to a minimum of 10 minutes. If your Mars rover is heading toward a cliff, you won't find out until at least 10 minutes later — at which time the unwary exploration device will have tumbled over the precipice.

A new generation of technology will be required for planet-roving vehicles. Getting a rover to Mars is really no problem at all. Designs are in hand that show how one could be attached to a Viking lander in place of many of the experiments that are now being prepared to go to Mars. The control of the rover is the problem. At present the advantages of having a roving device on Mars seem to be outweighed by the complexities of its control. The Future Exploration of Mars Study Panel has placed the Mars rover as a low priority behind several other possible missions to the red planet.

The most unusual of these alternative missions is known as the Mars *penetrator* scheme. This novel concept involves dropping ballistic devices from Martian orbit. The rocket shaped probes — about six feet long and six inches in diameter — would plunge into the planet at 350 m.p.h., implanting themselves 5 to 30 feet deep depending on the nature of the surface material. Instruments inside the penetrators would measure seismic activity, conduct some soil and rock analysis, and search for subsurface water. Four to six penetrators would be placed at strategic locations over the planet including the polar caps. Their one year design lifetime would provide a global seismic network and geophysical analysis that would be a comparative bargain at the \$80 million projected cost of the penetrator concept.

A plan to put the spare Viking orbiter into a 600 mile circular polar orbit of Mars in 1980 also gets a high priority from the Mars study panel. With a two year probable lifetime, the craft would fill in all the gaps from Mariner 9 and Viking as well as giving the polar areas their first detailed scrutiny.

As for manned flights to Mars, nobody talks about them anymore. The last study that was made suggested a cost of \$100 billion for a full scale manned mission. That's obviously a venture for future generations. 



Viking Science

ORBITER

Imaging — The two high resolution television cameras will aid in the certification of the assigned landing sites or the selection of new sites. The cameras will thoroughly map and monitor the chosen sites. Further orbital imaging will greatly extend our knowledge of the planet — particularly in regard to the volcanic, erosional and atmospheric phenomena on Mars.

Atmospheric Water Detector — The orbiter's infrared spectrometer will map the atmospheric water vapor over the landing sites and other portions of the planet. The instruments will also provide information on the daily and seasonal changes in humidity. The instruments are sensitive enough to detect one micron of precipitable water.

Thermal Mapper — An on board infrared radiometer will determine the surface temperatures and search for unusual hot spots. The temperature of frost or clouds will be measured. Measurements will be taken on the dark as well as the solar side of the planet.

Radio Science — These tests will use the telecommunication systems on both the lander and orbiter to refine data on Mars' gravitational field, axis of rotation, the shape of the planet, atmospheric structure, ionospheric properties, and motion of the planet's natural satellites.

LANDER

Space Entry — Several instruments will define the present physical and chemical state of Mars' atmosphere. Measurements will be taken during the descent, from the uppermost limits of Mars' atmosphere down to the surface. Data will clear up inconsistencies and provide a comprehensive model of Mars' atmosphere.

Imaging — Cameras on the lander will take stereo photos in color and black and white of the landing site. The cameras are capable of taking pictures from the lander's footpad to 40 degrees above the horizon. The photos will be used to characterize the landscape geologically, to look for evidence of life, and to support other experiments designed to measure the magnetic and physical properties of Mars' surface. The cameras will particularly aid in the selection of surface areas to be sampled.

Biology — The three biological experiments are described fully on page 10.

Molecular Analysis — There are two parts to this experiment — a mass spectrometer capable of detecting most atmospheric compounds and a gas chromatograph that will test and analyze soil samples to corroborate the biological experiments.

Inorganic Chemical Analysis — An X-ray spectrometer will determine as well as possible the abundances of various elements in the soil and rocks in the vicinity of the lander. The data should shed some light on the ancient and recent processes that make up the planet's history.

Meteorology — Sensors will sample the atmosphere near the lander; pressure, temperature, and wind velocity will be measured. This will be our first chance to accurately study the Martian weather.

Seismology — A small seismometer weighing several pounds will be mounted in each of the landers and coupled to the ground through the landing-leg assembly. They will measure ground tremors due to seismic activity.

Magnetic Properties — An array of permanent magnets will be located on the sampling boom so they can be brought into contact with the surface. The clinging magnetic particles will be photographed, and by using magnets of various strengths, the ferromagnetic characteristics of the surface will be determined.

Viking landers will therefore scoop up their soil samples and drop them into a hopper for analysis.

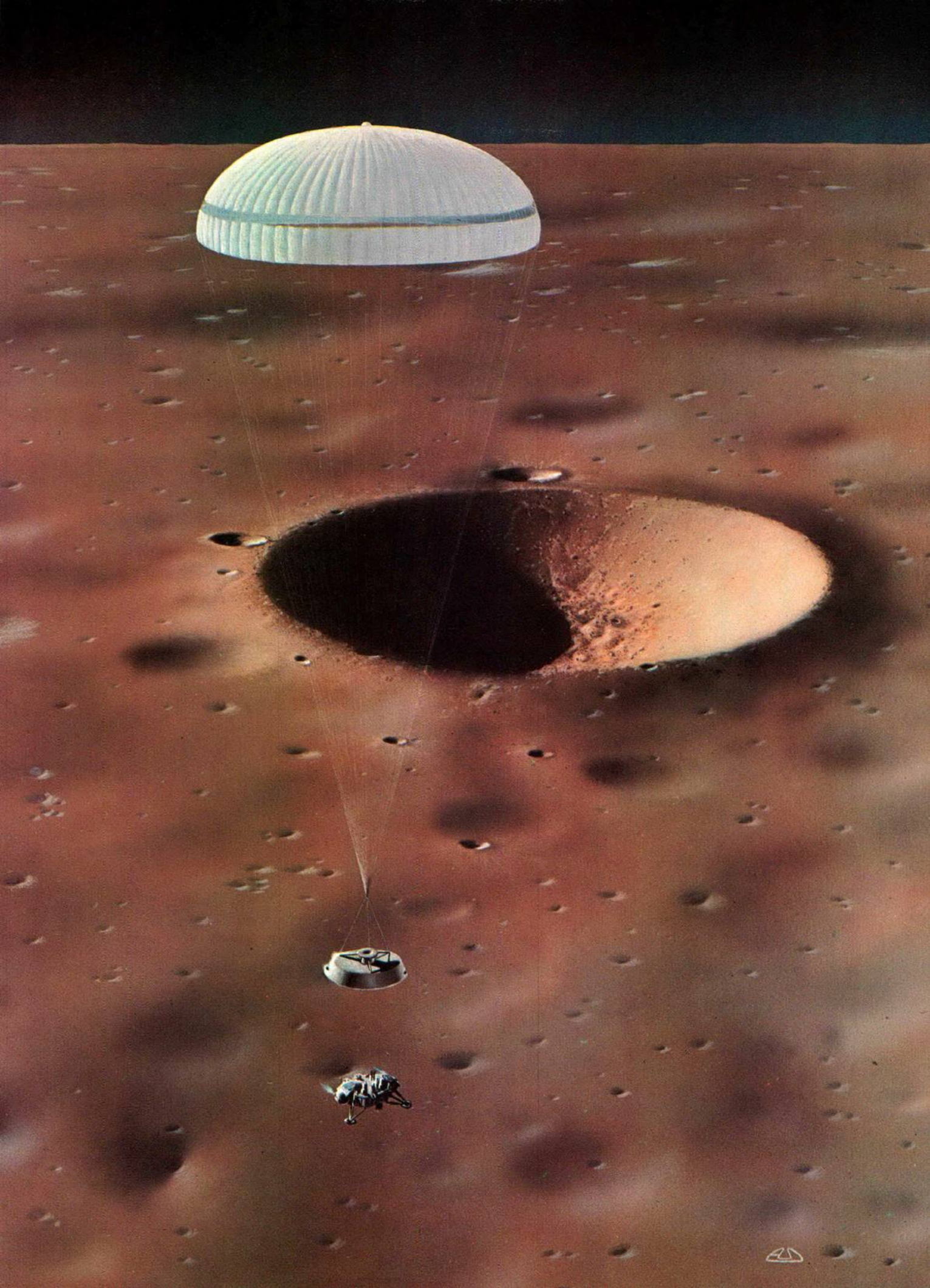
The first operation on the samples will not, however, be aimed solely at the detection of life. It will instead be a simple analysis of the soil carried out by an X-ray fluorescence spectrometer in which a sample can be irradiated with X-rays. The X-rays which are then emitted from the sample as fluorescence can be used to calculate the identities and abundances of the elements in the soil. This device will detect and measure all elements heavier than carbon, and it will provide a strong indication of whether the soil contains living organisms or

their remains. A one-to-one ratio of carbon to oxygen, for instance, would suggest the presence of carbohydrates such as cellulose [carbohydrates typically have the basic structure of $(CH_2O)_n$]. A one-to-three ratio would only suggest the presence of carbonate minerals such as limestone ($CaCO_3$).

A second experiment which is not specifically

The thin Martian atmosphere is dense enough to permit a safe parachute entry for the Viking lander. The chute opens at 20,000 feet for a descent to 5,000 feet where the engines ignite for a powered touchdown. The nearby five mile diameter crater is part of the Cydonia region landing site selected for the Viking 2 mission.

Artwork by Adolf Schaller

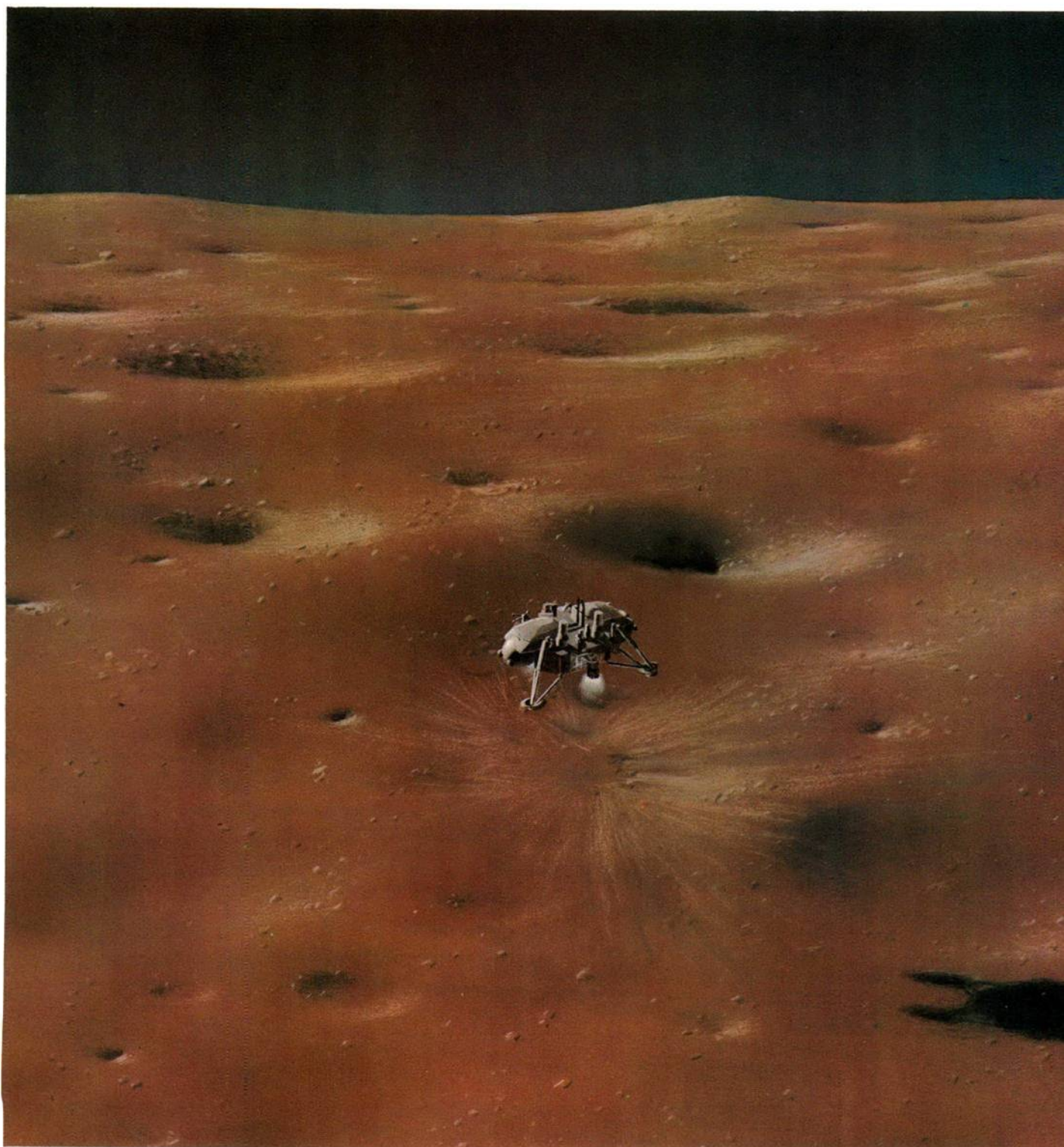


biological will be the gas chromatograph/mass spectrometer. This instrument is capable of analyzing samples of the atmosphere. It can also identify molecules given off by soil samples heated to their

Only seconds before touchdown, the Viking lander hovers before shutting down its engines and gently dropping to the Martian surface to begin mankind's first quest for life on another world. Even if life is not detected, our knowledge of the most Earthlike planet will be vastly increased by the accomplishments of these robot explorers.

Artwork by Adolf Schaller

vaporization point. The device has been tested on both synthetic mixtures and a portion of a meteorite, and it has proven capable of detecting organic molecules as well as inorganic ones. The results it obtains on Mars, however, will only be suggestive — even if it does discover organics. As our analyses of lunar soil have shown, organic type molecules may be found where life has never been. The three experiments designed to specifically search for life are described in detail in the accompanying article on page 10.



If there are any living cells of the kind we know in the Martian soil, the Viking landers should find them. The three tests they will apply are all based on a feature common to all life on Earth — although not on the only such feature available. All Earthly cells divide, too, as should all possible cells based on other chemistries. The Viking designers were once considering an experiment that would have exploited this feature. A soil sample would have been dumped into a glass vial filled with water and nutrients, and a beam of light would have been



directed through the vial onto a detector. As the cells then grew and multiplied, the water would have become murky, and less light would have made it through the vial. The detector would have sensed the change and reported life. But this experiment depends upon a very specific set of conditions — it requires lots of water — and Martian cells could be so adapted to dry conditions that they would not be able to breed in a wet environment. The experiments that will land on Mars are more versatile. They offer options that will allow us to vary the conditions according to the results already in, and they offer us the best chance of detecting life that we can devise.

They are not foolproof, however. These experiments have been designed to operate well under the low pressure, cold, dry conditions of Mars, and only the label release experiment has been adequately tested on Earth. Most Earthly organisms will simply not perform with the necessary vigor under Martian conditions — even though the sensitivities of the various detectors are phenomenally high. The other two experiments have therefore had to be tested only in principle. They should work — but they may not.

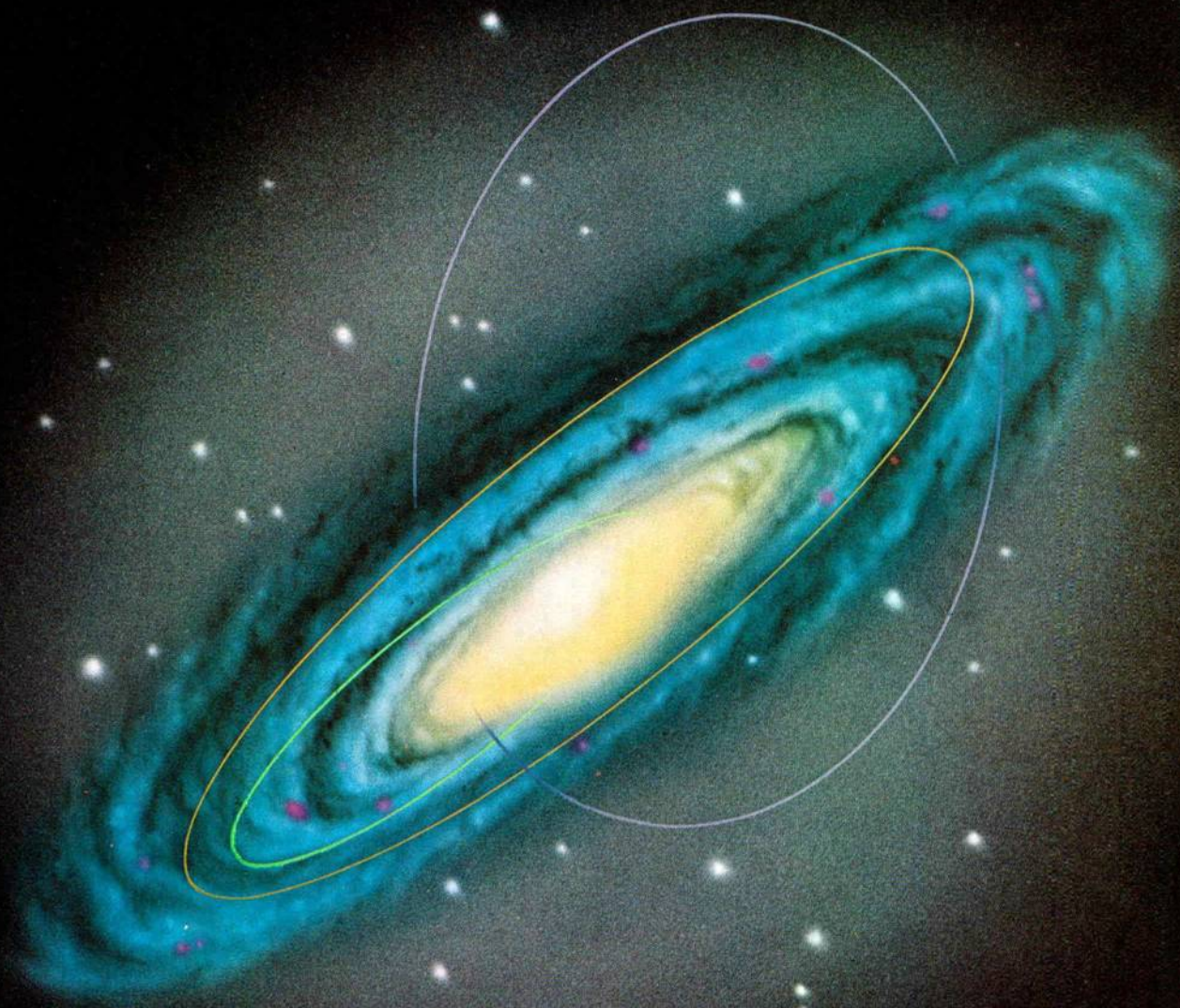
The Viking life detectors will not detect life if it is not there to be found. If Martian life exists only near the poles, or only deep beneath the surface sands, or only near the rare volcanic vents, or in some place the landers are not, the detectors will certainly fail. They may pick up some signs of life — the organic dusts and vapors that once belonged to life — but this will not be enough to satisfy us. Anything less than a living cell will leave us wondering whether we have found only remnants of the primordial molecules or whether we have found something more.

Such a failure will not, however, be any proof that Mars is sterile. It will only leave us still uncertain, for we know enough to believe that life *should* be there. Failure will only shake our faith, not topple it.

Mars should harbor some kind of life — and where life exists at all, it is everywhere (either active or dormant). We have every right to expect Viking to succeed in its search, and Viking's success will demonstrate what we now believe to be true: Life is not sacred to Earth.

In the words of biologists Cyril Ponnampereuma and Harold Klein: "We cannot escape the conclusion that there is nothing unique about the origin of life on Earth and that the interplay of cosmic forces and matter would have given rise to a similar sequence of events on countless numbers of planetary systems in the universe." We are rushing headlong to Mars to see for ourselves. 🐾

Dr. Thomas A. Easton is a textbook editor, freelance writer and theoretical biologist. He has written popular and scientific articles on the origin of life.



The Age of Nearby Stars

by
Jeffrey L. Kretsch

When we scan the myriad stars of the night sky, are we looking at suns that have just ignited their nuclear fires — or have they been flooding the galaxy with light for billions of years? The ages of the stars are among the most elusive stellar characteristics. Now, new interpretation of data collected over the past half century is shedding some light on this question.

All stars in the Milky Way galaxy have vast orbits around the galactic core. Any particular star requires millions of years to complete its orbit — the sun, for example, takes 230 million years. A star like the sun, in our part of the galaxy, will have an orbit similar to that traced out by the orange line. Such orbits identify Population I stars — basically solar type stars. Older stars are known to have more elliptical orbits either in the plane of the galaxy (Disk Population II, green line) or well beyond the main wheel shape of the Milky Way (Halo Population II, violet line). By determining its orbit and by collecting other data, astronomers can estimate a star's age. As discussed in this article, the age of a star is an elusive but valuable piece of information.

Artwork by Victor Costanzo

The age of our own sun is known with some accuracy largely because we live on one of its planets. Examination of Earth rocks — and, more recently, rocks and soil from the moon — has conclusively shown that these two worlds went through their initial formation 4.6 billion years ago. The formation of the sun and planets is believed to have been virtually simultaneous, with the sun's birth producing the planetary offspring.

But we have yet to travel to any other planet — and certainly a flight to the surface of a planet of a nearby star is an event no one reading this will live to witness. So direct measurement of the ages of nearby stars — as a by-product of extra-solar planetary exploration — is a distant future enterprise. We are left with information obtained from our vantage point here near Earth. There is lots of it — so let's find out what it is and what it can tell us.

Computer models of stellar evolution reveal that stars have definite lifespans; thus, a certain type of star cannot be older than its maximum predicted lifespan. Solar type stars of spectral class F5 or higher (hotter) cannot be older than our sun is today. These stars' nuclear fires burn too rapidly to sustain them for a longer period, and they meet an early death.

All main sequence stars cooler than F5 can be as old or older than the sun. Additionally, these stars are also much more likely to have planets than the hotter suns. (Details on the reasoning behind this assumption can be found in "The Zeta Reticuli Incident", December 1974.)

There are several exciting reasons why the age of a star should be tracked down. Suppose we have a star similar to the sun (below class F5). If we determine how old the star is, we can assume its planets are the same age — a fascinating piece of information that suggests a host of questions: Would older Earthlike planets harbor life more advanced than us? Is there anything about older or younger stars and planets that would make them fundamentally different from the sun and Earth?

Of course we don't know the answer to the first question, but it is provocative. The answer to the second question seems to be yes (according to the evidence that follows).

To best illustrate the methods of star age determination and their implications, let's select a specific problem. "The Zeta Reticuli Incident"

sparked more interest among our readers than any other single article in ASTRONOMY's history. (Some of the comments fill In Focus this month.) Essentially, that article drew attention to a star map allegedly seen inside an extraterrestrial spacecraft. The map was later deciphered by Marjorie Fish, now a research assistant at Oak Ridge National Laboratory in Tennessee.

In her analysis, Ms. Fish linked all 16 prominent stars in the original map (which we'll call the Hill map since it was drawn by Betty Hill in 1966) to 15 real stars in the southern sky. The congruence was remarkable. The 15 stars — for convenience we will call them the Fish-Hill pattern stars — are listed on the accompanying table.

Since these stars have been a focus of attention due to Ms. Fish's work and the article mentioned above, we will examine them specifically to see if enough information is available to pin down their ages and (possibly) other characteristics. This will be our case study star group.

Consider, for example, the velocities of these stars in space. It is now known that the composition and the age of a star shows a reasonably close correlation with that star's galactic orbit. The understanding of this correlation demands a little knowledge of galactic structure.

Our galaxy, as far as we are concerned, consists essentially of two parts — the halo, and the disk. Apparently when the galaxy first took shape about 10 billion years ago, it was a colossal

The Fish-Hill Pattern Stars

Gliese Catalog No.	Alternate Name	Spectral Type	W- Velocity	Total Space Velocity	Galactic Orbit Eccentricity	Galactic Orbit Inclination
17	Zeta Tucanae	G2	-38	70	0.1575	.0529
27	54 Piscium	K0	10	45	0.1475	.0260
59	HD 9540	G8	1	26	0.0436	.0133
67	HD10307	G2	0	45	0.1057	.0092
68	107 Piscium	K1	3	43	0.1437	.0134
71	Tau Ceti	G8	12	36	0.2152	.0287
86	HD13445	K0	-25	129	0.3492	.0269
86.1	HD13435	K2	-37	41	undetermined	undetermined
95	HD14412	G5	-10	33	0.1545	.0025
97	Kappa Fornax	G1	-13	35	0.0186	.0078
111	Tau 1 Eridani	F6	14	81	0.0544	.0078
136	Zeta 1 Reticuli	G2	15	79	0.2077	.0321
138	Zeta 2 Reticuli	G1	-27	127	0.2075	.0340
139	82 Eridani	G5	-12	37	0.3602	.0310
231	Alpha Mensae	G5	-13	22	0.1156	.0065
Sun	Sol	G5	0	0	0.0559	.0091

All the stars listed here are main sequence or spectral group V stars. Tau Ceti has a slight peculiarity in its spectrum as explained in the text. W-velocity is the star's motion in km/sec in a direction above or below (-) in the galactic plane. Total space velocity relative to the sun is also in km/sec. Data is from the *Gliese Catalog of Nearby Stars* (1969 edition).

sphere in which the first generation of stars emerged. These stars — those that remain today, anyway — define a spherical or halolike cloud around the disk shaped Milky Way galaxy. Early in the galaxy's history, it is believed that the interstellar medium had a very low metal content because most of the heavy elements (astronomers call any element heavier than helium "heavy" or a "metal") are created in the cores of massive stars which then get released into the interstellar medium by stellar winds, novae and supernovae explosions. Few such massive stars had "died" to release their newly made heavy elements. Thus, the stars which formed early (called Population II stars) tend to have a spherical distribution about the center of the galaxy and are generally metal-poor.

A further gravitational collapse occurred as the galaxy flattened out into a disk, and a new burst of star formation took place. Since this occurred later and generations of stars had been born and died to enrich the interstellar medium with heavy elements, these disk stars have a metal-rich composition compared to the halo stars. Being in the disk, these Population I stars (the sun, for example) tended to have motions around the galactic core in a limited plane — something like the planets of the solar system.

Population II stars — with their halo distribution — usually have more random orbits which cut through the Population I hoards in the galactic plane. A star's space velocity perpendicular to the galactic plane is called its *W-velocity*. Knowing the significance of the *W-velocity*, one can apply this information to find out about the population classification and hence the ages and compositions of stars in the solar neighborhood — the Fish-Hill stars in particular.

High *W-velocity* suggests a Population II star, and we find that six of the 16 stars are so classified while the remaining majority are of Population I. A further subdivision can be made using the *W-velocity* data (the results are shown in the table on page 26).

According to this classification system (based on one by A. Blaauw), most of the 16 stars are in the same class as the sun — implying that they are roughly of the same composition and age as the sun. The sun would seem to be a natural unit for use in comparing the chemical compositions and ages of the stars of the Fish-Hill pattern because it is, after all, the standard upon which we base our selection of stars capable of supporting life.

Three stars (Gliese 59, 67 and 68) are known as Old Population I and are almost certainly younger than the sun. They also probably have a higher metal content than the sun, although specific data is not available. The Disk Population II stars are perhaps two to four billion years older than the sun, while the Intermediate Population II are believed to be a billion or two years older still.

Characteristics of the Fish-Hill Pattern Stars

All 16 stars are:

- main sequence type stars between spectral class F5 and K5, and thus have sufficient life-spans to allow life to evolve on any Earthlike planets.
- not members of multiple star systems except in cases where the components are widely separated.
- not variable in energy output according to most recent data.
- within 50 light-years of the sun.

For main sequence stars like the sun, as all these stars are, it is generally believed that after the star is formed and settled on the main sequence no mixing between the outer layers and the thermonuclear core occurs. Thus the composition of the outer layers of a star, (from which we receive the star's light) must have essentially the same composition as the interstellar medium out of which the star and its planets were formed.

Terrestrial planets are composed primarily of heavy elements. The problem is: If there is a shortage of heavy elements in the primeval nebula, would terrestrial planets be able to form? At present, theories of planetary formation are unable to state for certain what the composition of the cloud must be in order for terrestrial planets to materialize, although it is agreed to be unlikely that Population II stars should have terrestrial planets. But for objects somewhere between Populations I and II — especially Disk Population II — no one really knows.

Although we can't be certain of determining whether a star of intermediate metal deficiencies can have planets or not, we can make certain of the existence of metal deficiencies in those stars. The eccentricities and inclinations of the galactic orbits of the Fish-Hill stars provide the next step in the information sequence.

The table on page 24 shows that the stars Gliese 136, 138, 139, 86 and 71 have the highest eccentricities and inclinations in their galactic orbits. This further supports the Population II nature of these four stars. According to B.E.J. Pagel of the Royal Greenwich Observatory in England, the correlation between eccentricity and the metal/hydrogen ratio is better than that between the *W-velocity* and the metal/hydrogen ratio. It is interesting to see how closely the values of eccentricity seem to correspond with Population type as derived from *W-velocity* — Old Population I objects having the lowest values. Since the two

methods give similar results, we can lend added weight to our classification.

So far all the evidence for metal deficiencies has been suggestive; no direct evidence has been given. However, specific data can be obtained from spectroscopic analysis. The system for which the best set of data exists also happens to be one of the most important stars of the pattern, Zeta 1 Reticuli. In 1966, J. D. Danziger of Harvard University published results of work he had done on Zeta 1 Reticuli using wide-scan spectroscopy. He did indeed find metal deficiencies in the star: carbon, 0.2, compared to our sun; magnesium, 0.4; calcium, 0.5; titanium, 0.4; chromium, 0.3; manganese, 0.4; iron, 0.4; cobalt, 0.4; nickel, 0.2, and so on.

In spite of the possible error range of about 25 percent, there is a consistent trend of metal deficiencies — with Zeta 1 Reticuli having less than half the heavy elements per unit mass that the sun does. Because Zeta 1 Reticuli has common proper motion and parallax with Zeta 2 Reticuli, it probably also has the same composition. Work done by M. E. Dixon of the University of Edinburgh showing the two stars to have virtually identical characteristics tends to support this.

The evidence that the Zeta Reticuli system is metal deficient is definite. From this knowledge of metal deficiency and the velocities and eccentricities, we can safely conclude that the Zeta Reticuli system is older than the sun. The question of terrestrial planets being able to form remains open.

The other two stars which have high velocities and eccentricities are 82 Eridani (Gliese 139) and Gliese 86. Because the velocities of these stars are higher than those of Zeta Reticuli, larger metal deficiencies might be expected. For the case of Gliese 86, no additional information is presently available. However, some theoretical work has been done on 82 Eridani concerning metal abundances by J. Hearnshaw of France's Meudon Observatory.

Although 82 Eridani is a high velocity star, its orbit lies largely within the galactic plane, and also within the solar orbit. Its orbit is characteristic of the Old Disk Population, and an ultra-violet excess indicates only a mild metal deficiency compared to the sun. Hearnshaw's conclusions indicate that the metal deficiency does not appear to be any worse than that of the Zeta Reticuli pair.

Because Gliese 86 has a velocity, eccentricity and inclination similar to 82 Eridani, it seems likely that its chemical composition may also not have severe metal deficiencies, but be similar to those of 82 Eridani.

Tau Ceti appears to be very much like the sun except for slight deficiencies of most metals and rarely seen abnormal abundances of magnesium, titanium, silicon and calcium. Stars in this class are known as alpha-rich stars, but such properties do not appear to make Tau Ceti unlikely to have planets similar to the sun's.

Tau 1 Eridani, an F6V star, has a life expectancy of 4.5 billion years — so it cannot be older than the sun. The low eccentricities and low moderate velocity support an age and composition near that of the sun.

Gliese 67 is a young star of at least solar metal abundances, considering its low velocity and eccentricity.

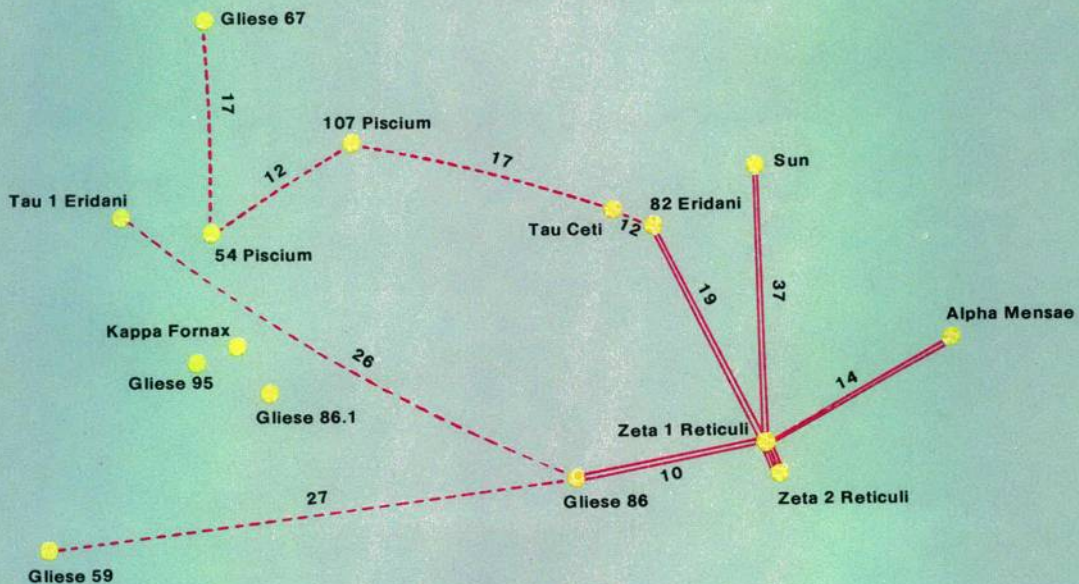
Having covered most of the stars either directly or simply by classifying them among the different Population classes, it is apparent that there is a wide age range among different stars of this group as well as a range of compositions. It is curious that the stars connected by the alleged "trade routes" (solid lines) are the older and occasionally metal deficient ones — while the stars connected by dotted lines seem to be younger Population I objects.

A final point concerning the metal deficiencies is rather disturbing. Even though terrestrial planets might form about either star in the Zeta Reticuli system, there is a specific deficiency in carbon to

Population Classification of the Fish-Hill Stars

Old Population I (1 to 4 billion years old)	Older Population I (4 to 6 billion years old)	Disk Population II (6 to 8 billion years old)	Intermediate Population II (about 10 billion years old)
Gliese 59	Tau Ceti	Zeta 1 Reticuli	Zeta Tucanae
Gliese 67	Gliese 95	Zeta 2 Reticuli	Gliese 86
107 Piscium	54 Piscium		Gliese 86.1
	Tau 1 Eridani		82 Eridani
	Alpha Mensae		
	Kappa Fornax		
	Sun		

The Fish Interpretation Stars



Numbers on lines are distances in light-years between stars.

The controversial interpretation of the Hill "star map" conducted by Marjorie Fish includes the sun and 15 nearby stars. These stars make an ideal case study for stellar age determina-

tion as described in this article. For further details specifically about this map, see *In Focus* and the December 1974 issue.

well within the error range. This is disturbing because carbon is the building block of organic molecule chains. There is no way of knowing whether life on Earth would have emerged and evolved as far as it has if carbon were not as common here.

Another problem: If planets formed but lacked large quantities of useful industrial elements, could a technical civilization arise? If the essential elements were scarce or locked up in chemical compounds, then an advanced technology would be required to extract them. But the very shortage of these elements in the first place might prevent this technology from being realized. The dolphins are an example of an intelligent but nontechnical race. They do not have the means to develop technology. Perhaps some land creatures on another planet are in a comparable position by not having the essential elements for technological development. (This theme is explored in detail in "What Chariots of Which Gods?", August 1974.)

This whole speculation certainly is not strong enough to rule out the Fish interpretation of the

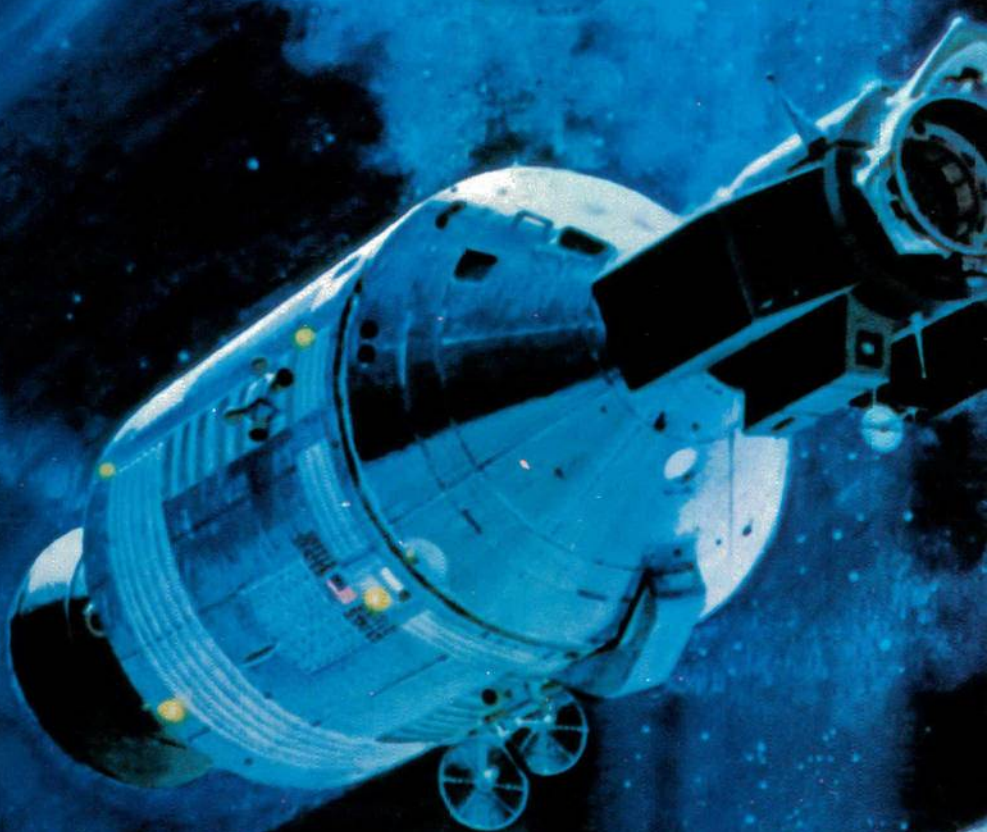
Hill map given our present state of knowledge. Actually in some respects, the metal deficiencies support the Fish hypothesis because they support an advanced age for several of the stars — suggesting that if cultures exist in these star systems, they might well be advanced over our own.

The fact that none of the stars in the pattern is seriously metal deficient (especially the vital branch high velocity stars 82 Eridani and Gliese 86) is an encouragement to the Fish interpretation — if terrestrial planets can form in the first place and give rise to technical civilizations. Once again we are confronted with evidence which seems to raise as many questions as it answers. But the search for answers to such questions certainly can only advance our knowledge of our cosmic environment. 🐟

*Jeffrey L. Kretsch is an astronomy student at Northwestern University working under the advisement of Dr. J. Allen Hynek. For more than a year Kretsch has been actively pursuing follow-up studies to the astronomical aspects of the Fish-Hill map. More of his studies and comments appear in *In Focus*.*

An International Space Venture

by
James E. Oberg





McCall, 74

American and Soviet manned spaceships have conducted more than 30 space dockings since the Gemini 8 mission first succeeded in 1966. The next space docking will be the Apollo/Soyuz Test Project (ASTP) — a revolutionary new type of orbital linkup. For the first time in the brief history of the space age, spacecraft launched from two different countries will conduct a combined space mission.

The purpose of the ASTP effort is basic but far-reaching: evaluate the procedures and equipment for future international space cooperation. Soviet and American space engineers have spent three years working together and comparing different approaches. They have developed special equipment and unique techniques for this unprecedented hookup.

The practical lessons learned in ASTP will have important future applications. In the most dramatic case, a spaceship from one country may be able to

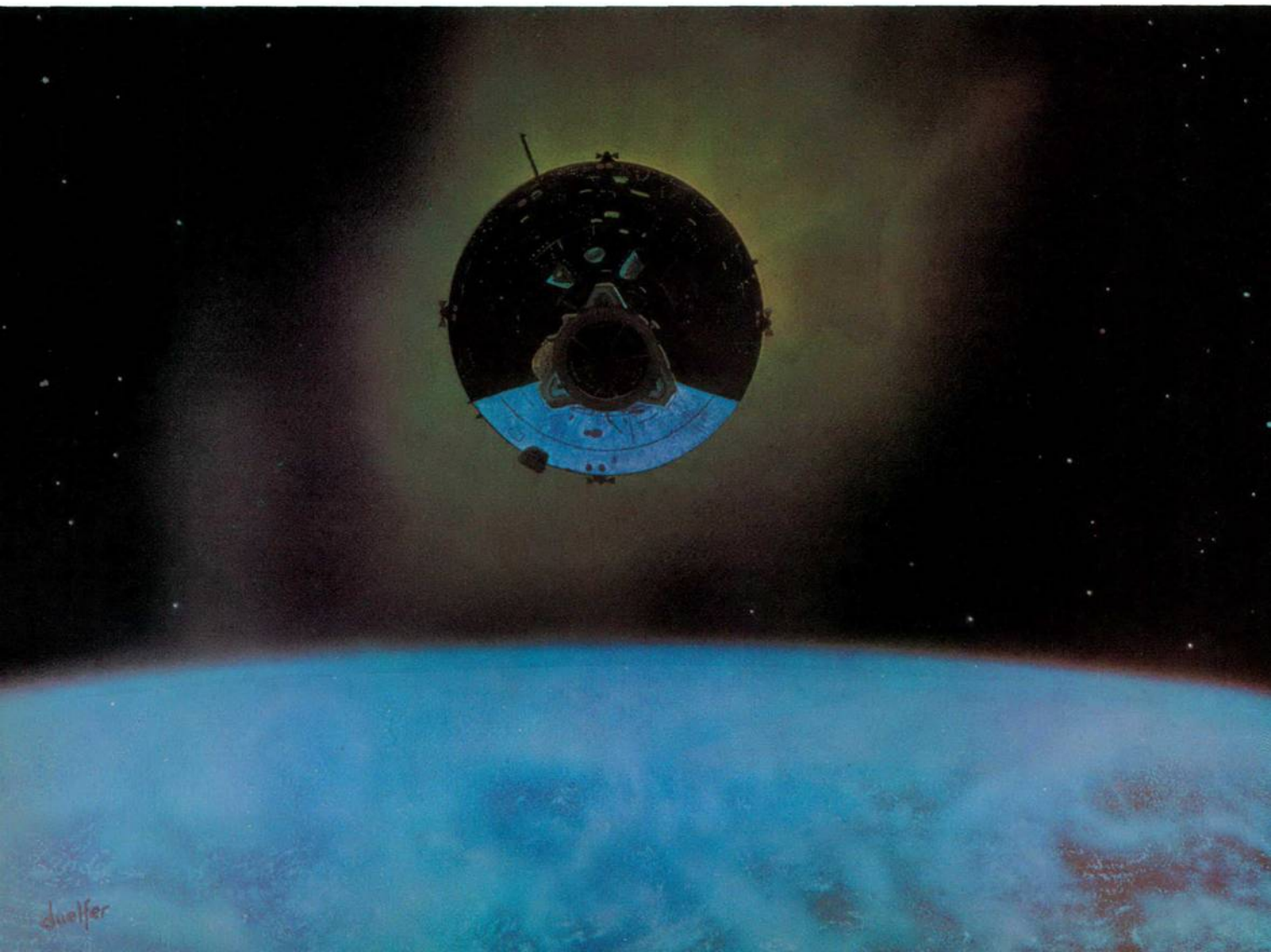
rescue endangered spacemen from another country. More ordinary applications would involve astronauts and cosmonauts visiting each others' orbital space laboratories, just as Russian and American scientists now exchange visits at the scientific bases in Antarctica.

The basic ASTP flight plan calls for first launching a two-man Soyuz capsule from the Soviet spaceport in central Asia on July 15, 1975. About 7-1/2 hours later, as Earth's rotation carries Cape Canaveral into the orbital plane of the Soviet spaceship, the Apollo chase spacecraft blasts off. After Apollo spends two days catching up to Soyuz, the ships rendezvous and dock in orbit. The two crews visit each other's spacecraft via a special docking adapter, and conduct joint activities. The Soyuz returns to Earth after six days in orbit; the Apollo crew will conduct experiments for several days longer in space.

While in orbit, the two ships will test the new standard docking equipment. Previous docking vehicles had to be equipped with opposite types of docking gear — like the plug and socket arrangement of electrical connectors. This new design (called *androgynous*, or *neuter*) will allow the two ships, or any other two ships with the same type of equipment, to dock. It functions more like the universal latch on

NASA Artwork by Robert McCall (pages 28-9)

The American Apollo spacecraft (left) slowly closes in to link up with the Soviet Soyuz vehicle in a symbolic space rendezvous, 140 miles above Earth. A petal-like docking mechanism on the black Docking Module between the ships captures and securely grasps the Soyuz. This historic flight will be the first test of this special universal docking system. It may someday allow U.S. and Soviet craft to routinely conduct joint space endeavors, or rescue crews from disabled spacecraft.



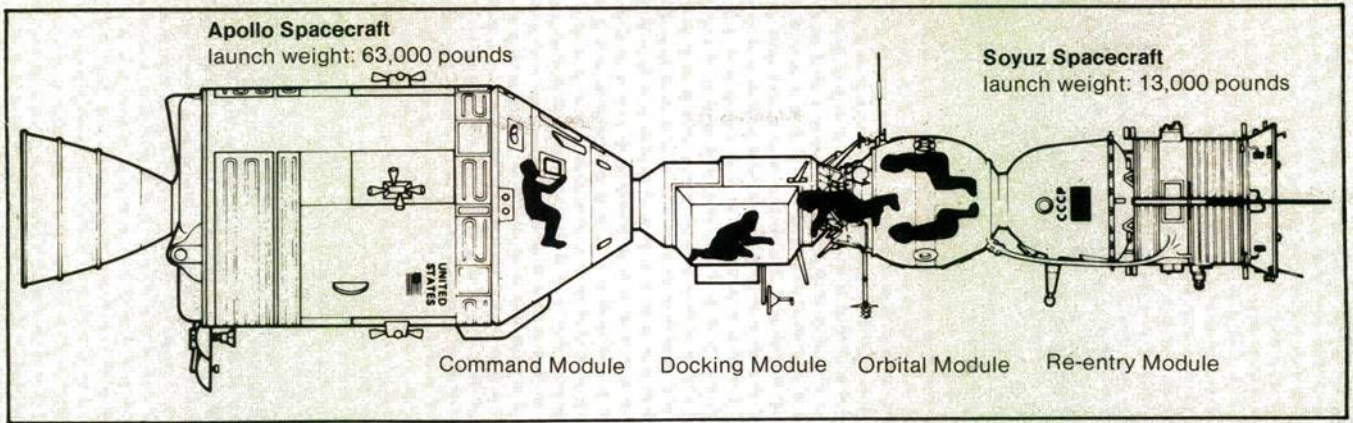


Diagram by Rockwell International

Apollo and Soyuz will spend three days in this docked configuration. Astronauts float from Apollo's cone shaped Command Module (left) through a special docking adapter to Soyuz's bulbous Orbital Module (right). Because the two

spacecraft have significantly different atmospheric pressures, this Docking Module is a necessary intermediate step. Its atmosphere will be alternately changed to conform to Apollo's or Soyuz's during crew transfers.

railroad cars. Both Soviet and American spacecraft of the future will be equipped with docking gear of this design.

A series of engineering and scientific experiments will be performed by the United States and Soviet crews. Refinements on Skylab data and some new experiments will both take place — covering such areas as astronomy, biology, metallurgy and Earth resources.

Apollo/Soyuz is one of a kind. It will be the last Apollo flight, and the last American manned space mission before the Space Shuttle begins flight tests in the late 1970s. Although neither country sees any reasons to duplicate the Apollo/Soyuz docking, further cooperation seems inevitable. ASTP will have important political implications when it "breaks the ice" for advanced forms of US-USSR space teamwork. Already, Soviet researchers have invited American scientists to fly some biology experiments on an unmanned Soviet satellite later this year (see *Astro-News*, March 1975). American and Soviet spacemen could test new space suit designs on Soyuz flights later in the 1970s, or visit the derelict Skylab to retrieve a space "time capsule" of engineering samples. Astronauts and cosmonauts could share training, tracking and recovery facilities. A Space Shuttle could launch a jointly-manned Soviet Salyut type space station in 1980.

Interwoven in all these visions of the future are the important political and diplomatic implications of Apollo/Soyuz. ASTP was born as a child of detente, and now has developed momentum of its own. In working together and linking up in space, perhaps the Soviet and American space engineers will encour-

How Important is the Apollo/Soyuz Project?

In a time of recession and general public disinterest in space missions, this manned flight will probably draw debate and skepticism over its purpose and value in the scheme of space exploration. We have already journeyed to the moon and kept men in orbit aboard the elaborate Skylab space station for months at a time. What can this mission add to man's future in space? In excerpts from a speech before the National Space Club late last year, Chester M. Lee, program director of the Apollo/Soyuz Test Project (ASTP), explains the flight's significance:

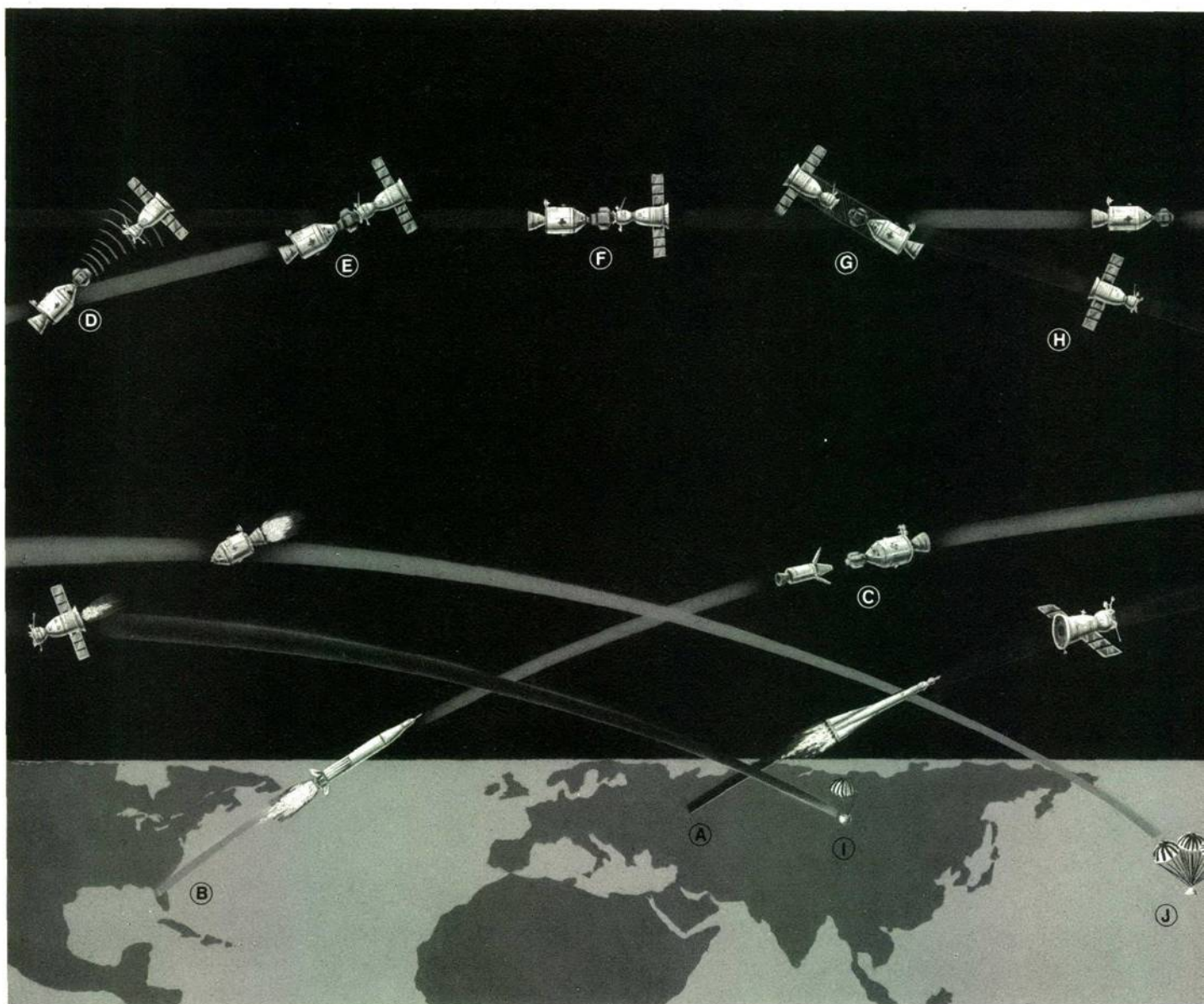
"...I believe it is important to acquire the necessary experience and basic information for joint space operations. I have in mind not only future rescue capabilities, but also joint space exploration. Obviously space exploration and utilization is expensive. One way to alleviate this cost is in joint ventures.

"ASTP also provides the opportunity to keep our momentum going in the interval before the Space Shuttle starts flying. It is easy for some to cast this aspect off — but NASA has developed a very fine government/industry/university team. Operations contribute a great deal to keeping such a team viable....

"The program has also provided a window — however small — into a part of the Soviet society. With this window and resulting knowledge and understanding, there is some contribution to detente." 

The sun's glowing outer corona silhouettes the Apollo spacecraft in this view from an automatic camera mounted on Soyuz. On the third day of joint activities, Apollo creates an artificial solar eclipse by flying 650 feet away from the Soviet craft. At this distance Apollo appears twice the sun's angular diameter, allowing photography of the extremely faint outer corona that is invisible through Earth's atmosphere.

Artwork by Charles A. Duelfer



age more contact, cooperation and understanding between Moscow and Washington. The symbolism of the "handshake in orbit" may have beneficial effects on Earth as well.

Astronomy Experiments on ASTP

Although the primary mission of the Apollo/Soyuz docking is to prove out techniques, equipment and procedures for Soviet-American joint space dockings, scientists have taken advantage of the opportunity to fly more than 20 hitchhiker experiments. Six of them are related to astronomy:

1) *Extreme Ultraviolet Astronomy* — Development of new detectors in the extreme ultraviolet will allow the first systematic searches in this wavelength. In theory, objects such as stellar coronas, dead pulsars, extremely hot stars, and accreting interstellar material should be intense ultraviolet sources.

2) *Measure the Interplanetary Helium Glow* — An extraterrestrial helium fluorescent radiation, first detected by rocket observations, will now be

surveyed extensively for the first time. An attempt will be made to measure the inflow of interstellar helium into the solar system. Similar interstellar hydrogen inflow has only recently been discovered, and these effects have considerable implications for stellar evolution.

3) *UV Absorption Experiment* — Density of atomic oxygen and nitrogen in the orbital path of the spaceships will be charted by the new technique of measuring the ultraviolet absorption in the medium between the Apollo and Soyuz spacecraft before they are docked. The boundary between the solar wind and the lower atmosphere will be better understood.

4) *Soft X-Ray Observations* — High resolution surveys of X-ray sources in the 0.1 to 1.0 thousand-electron-volt range will be conducted for the first time along with observations of more than 100 sources already detected by the Uhuru X-ray satellite. X-ray emissions from Earth's aurora will also be measured.

5) *Artificial Solar Eclipse* — Soviet cosmonauts

APOLLO/SOYUZ MISSION TIMETABLE

Date	Event	Time (EDT)
Tuesday, July 15	(A) Soyuz launch	8:20 a.m.
	(B) Apollo launch	3:50 p.m.
	(C) extract Docking Module from Saturn 1B upper stage	6:24 p.m.
Wednesday, July 16	Docking Module checkout	10:20 a.m.
	Apollo conduct independent experiments	all day
Thursday, July 17	(D) Apollo and Soyuz rendezvous	11:14 a.m.
	(E) docking	12:15 p.m.
	(F) first greeting between crews; Stafford and Slayton enter Soyuz, begin joint experiments	3:23 p.m.
	first transfer ends; astronauts return to Apollo	6:26 p.m.
	second transfer begins; Brand enters Soyuz, Leonov enters Apollo	4:59 a.m.
Friday, July 18	second joint activity period ends; third transfer begins; Leonov and Stafford enter Soyuz, Brand and Kubasov enter Apollo	11:08 a.m.
	third joint activity period ends; fourth transfer begins; Slayton and Kubasov enter Soyuz	3:06 p.m.
	Stafford and Slayton return to Apollo; farewell between U.S. and Soviet crews	6:10 p.m.
	(G) undock, perform solar eclipse experiment	8:02 a.m.
	second docking	8:40 a.m.
Saturday, July 19	(H) final separation	6:54 p.m.
	Soyuz and Apollo conduct independent activities	all day
Sunday, July 20		
Monday, July 21	(I) Soyuz landing	6:50 a.m.
Thursday, July 24	(J) Apollo landing	5:19 p.m.*

*tentative

will scan the solar corona in a number of wavelengths while the Apollo spacecraft acts as an occulting disk to generate an artificial eclipse.

6) *Light Flash* — The crew of Apollo 11 first noticed flashes of light when their eyes were closed. Experts believe that the flashes are triggered by cosmic rays striking the eyes or optic nerves. This experiment will use the human eye as a cosmic ray detector for measuring how cosmic ray density varies with the spacecraft's latitude relative to Earth's magnetic field.

Apollo/Soyuz Crewmen

Brigadier General *Thomas P. Stafford*, 44, has been an astronaut for 13 years. He helped pilot the first space rendezvous flight in 1965 and commanded another Gemini space rendezvous mission the following year. As commander of Apollo 10 in 1969, he carried out the "dress rehearsal" lunar orbital test of the Lunar Module which cleared the way for the Apollo 11 moon landing.

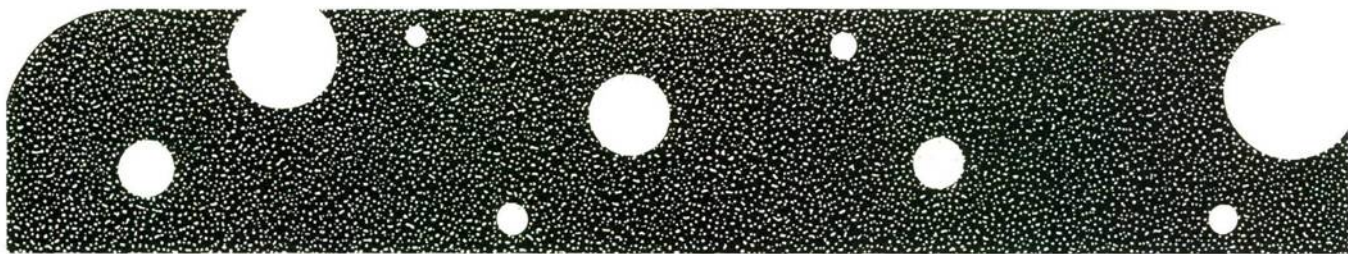
Civilian *Vance Brand*, 44, served on backup crews

for Apollo moon flights and Skylab missions and was crew commander of the Skylab-R rescue ship, which would have picked up the last Skylab crew in the event of trouble. This will be his first space flight after nine years of training.

Civilian *Donald K. (Deke) Slayton*, one of the original seven Mercury astronauts, was chosen to fly Mercury 7 in 1962 but was replaced a few weeks before the launch because of a subtle heart irregularity. For 10 years he was director of flight crew operations at the Houston space center, and he picked the crews of astronauts for all space missions. The medical problem cleared up in 1972. At 51, Slayton will be the oldest man ever to fly in space.

Colonel *Alexei A. Leonov*, 41, was the first man to walk in space (in 1965). He is known as the "artist-cosmonaut" for his space sketches and paintings.

Civilian *Valery N. Kubasov*, 40, a specialist in spacwalking and spacesuits, became a cosmonaut in 1966. He was a crewman on Soyuz 6 in 1969 and performed a series of space welding tests. 



STELLAR FRONTIERS

Mysteries of the Galactic Core

by

Gerrit L. Verschuur

Through today's telescopes, astronomers scan the far fringes of the visible universe — watching events occurring billions of light-years away. Meanwhile, the center of our own pinwheel shaped galaxy, the Milky Way, remains one of the most mysterious and uncharted regions of space. One major problem is that the sun, along with 250 billion other stars, dwells within the Milky Way's broad disk. Vast clouds of obscuring interstellar dust interlacing this disk drastically reduce optical telescopes' observational range (within the galactic plane) to a fraction of the Milky Way's 100,000 light-year diameter. This situation can be compared to standing in a suburb on a foggy night and trying to locate and sketch the center of the accompanying large city.

Clues about the nature of the galactic nucleus must be gathered in parts of the electromagnetic spectrum unaffected by dust — infrared, radio waves and X-rays. Two of these regions in particular — infrared and radio waves shorter than one meter — are allowing astronomers to peek into dynamic processes and unusual structures at the Milky Way's heart. Unraveling the shape and behavior of the nucleus is vital to an understanding of our galaxy's evolution. New insights into violent events detected in other galaxies could be an added bonus. Observations of radio galaxies, Seyfert galaxies and possibly quasars reveal that galactic nuclei are sometimes the focus of titanic explosions,

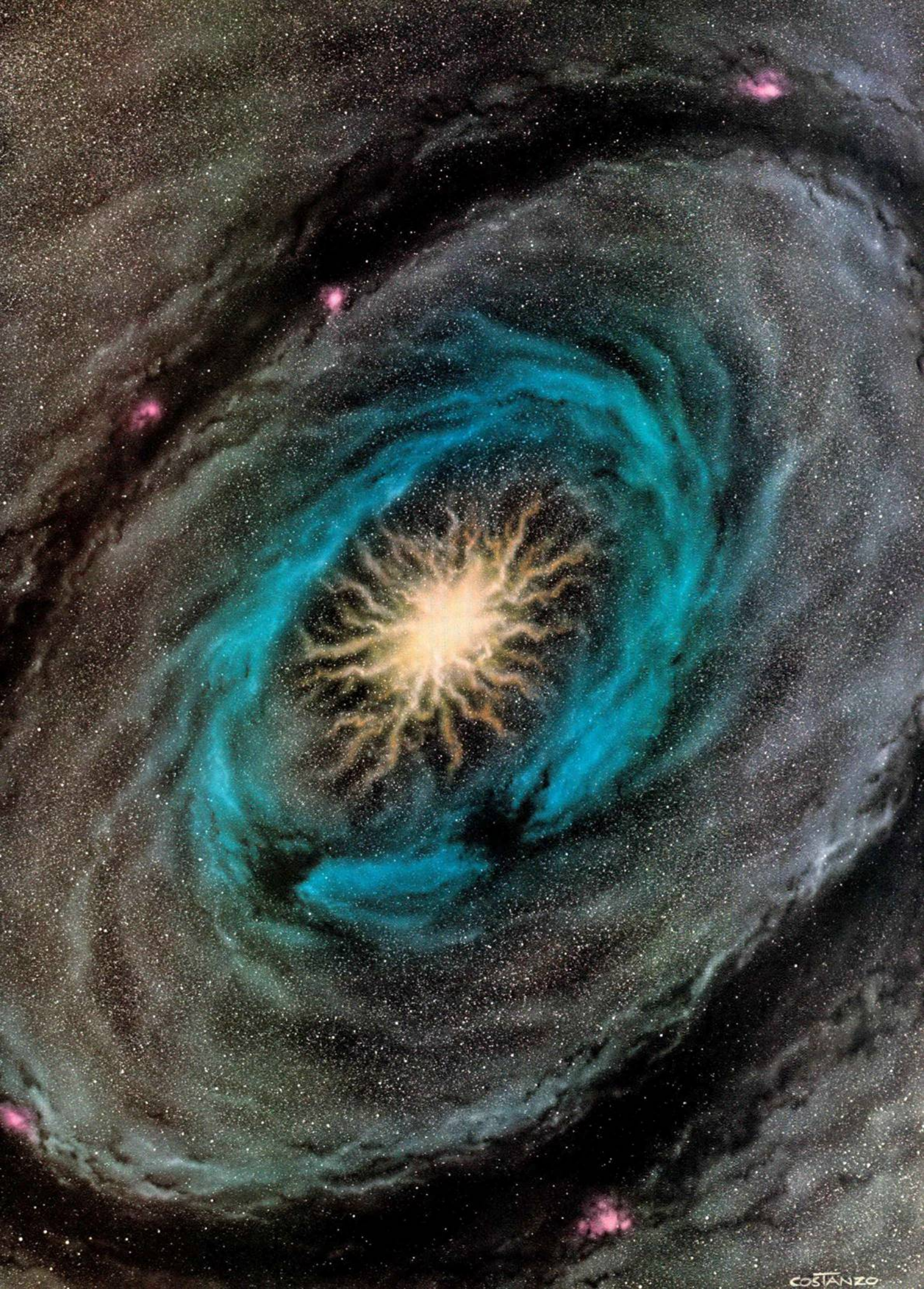
overwhelming in their energy output and scale of disruption.

In exploring the Milky Way's heart, the first problem was encountered in pinning down its exact location. Two simple observations pointed the way decades ago. Globular clusters, the oldest known collections of stars accompanying our galaxy, are distributed in a spherical region of space bisected by the Milky Way's disk. The center of this sphere of globular clusters, and hence the center of the galaxy, is located in the direction of the constellation Sagittarius. Early estimates placed the galactic center at a distance of 30,000 light-years from the sun. Currently there is talk of reducing that value to 27,000 light-years.

During the last few years, observations of radio signals from the densest parts of the Milky Way have allowed astronomers to zero in on the galaxy's center. Radio maps of the sky show a very strong radio source surrounded by several other weaker radio sources in the direction of Sagittarius, approximately where the center should be located according to the globular cluster data. Radio

Recent radio and infrared observations suggest that two titanic swirling rings of interstellar gas, dust and molecules occupy the core of our galaxy. Emission nebulae in the 1,800 light-year diameter outer ring locate regions where stars are being born. This bizarre double doughnutlike structure was apparently produced by an explosion 10 million years ago. Remnants of that mysterious blast linger at the center of the ring system.

Artwork by Victor Costanzo



data now pinpoints this central source to the incredible accuracy of a few seconds of arc and measures its diameter as being only about two light-years.

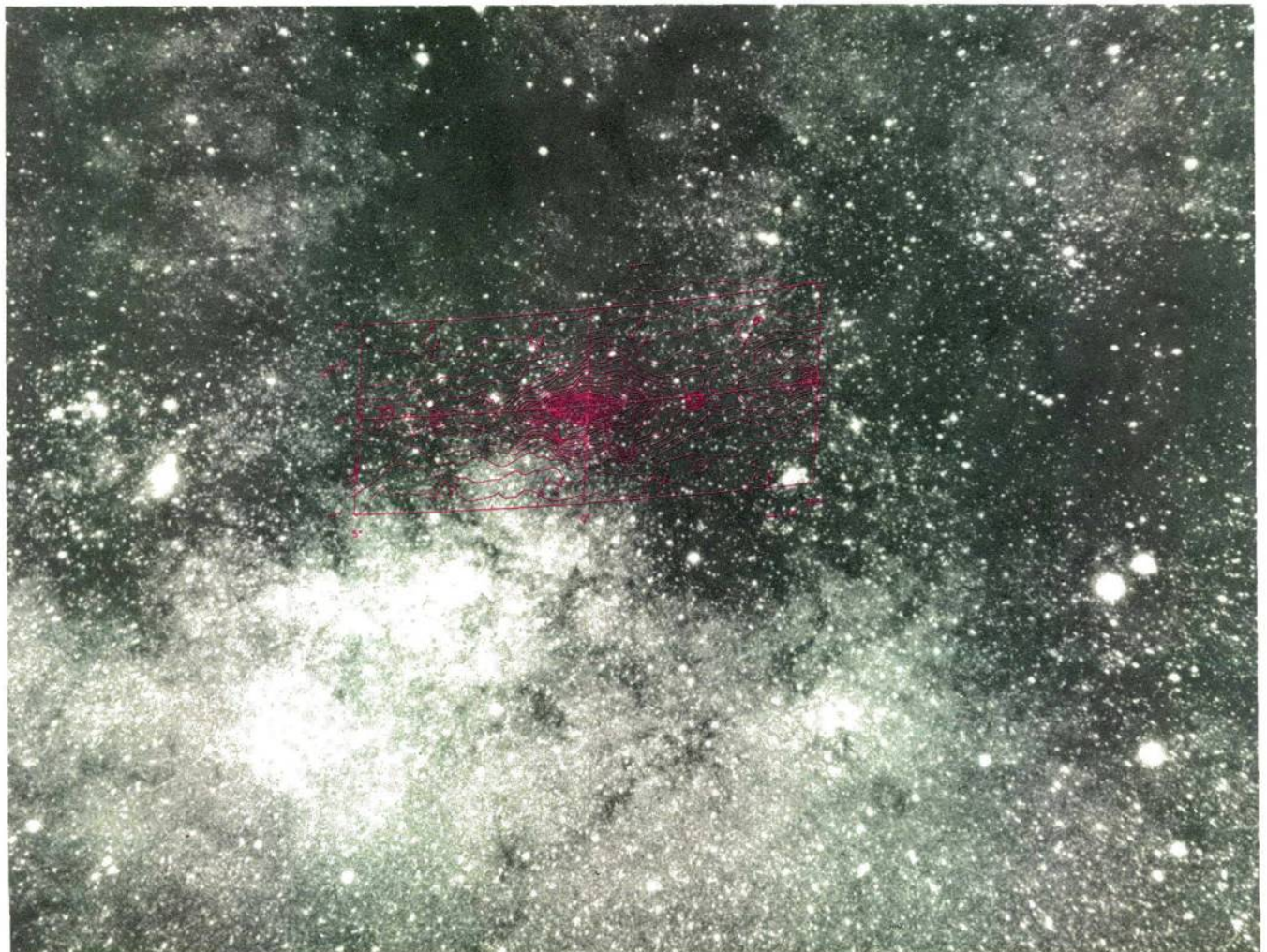
Confirming evidence that this is the central source comes from a considerable amount of infrared radiation emitted from the same location — infrared radiation so intense that it cannot be easily interpreted unless we believe that something very special is occurring there. Present explanations for the infrared hot spot propose that a very dense cluster of stars at the center is surrounded by a thick cloud of dust absorbing the light from the stars and reradiating it as heat. Having a diameter of a few light-years, this cluster contains the equivalent of a hundred million sunlike stars. Nevertheless, absolutely no light escapes through the enshrouding thick cloud.

More infrared radiation surrounding this very dense dust core indicates the presence of additional dust and stars. Apparently a large number of stars surrounding the nucleus cluster — occupying a region about 100 light-years across — are also cloaked by a dense dust shell. Only one trillionth of the light emitted by those stars escapes outward through the dust.

The strongest and smallest diameter radio source found in the galactic center seems to coincide exactly with the bright infrared core. The type of radio emission associated with that source (known as Sagittarius A) is produced by high energy electrons spiraling about magnetic field lines, and is usually associated with exploding stars or galaxies. This is called a *nonthermal source* — as opposed to a *thermal source*, like the hot gases found in the Orion nebula (one of many *emission nebulae*).

Although unusual, a nonthermal radio source in a region where there must be an enormous number of stars present is not entirely unexpected since such sources are found at the center of other galaxies. Having an incredible number of stars packed in a small volume of space apparently makes conditions favorable for matter to emit such radio signals.

In addition to Sagittarius A, there are several thermal emitters — large clouds of hot gas lying near the galactic center. Many young, hot stars heat the gas clouds, which in turn reradiate their energy as radio waves. The center of our galaxy is dotted with a half dozen or so of these very large emission nebulae — totally invisible to us, but detectable because of their strong radio signals. The most



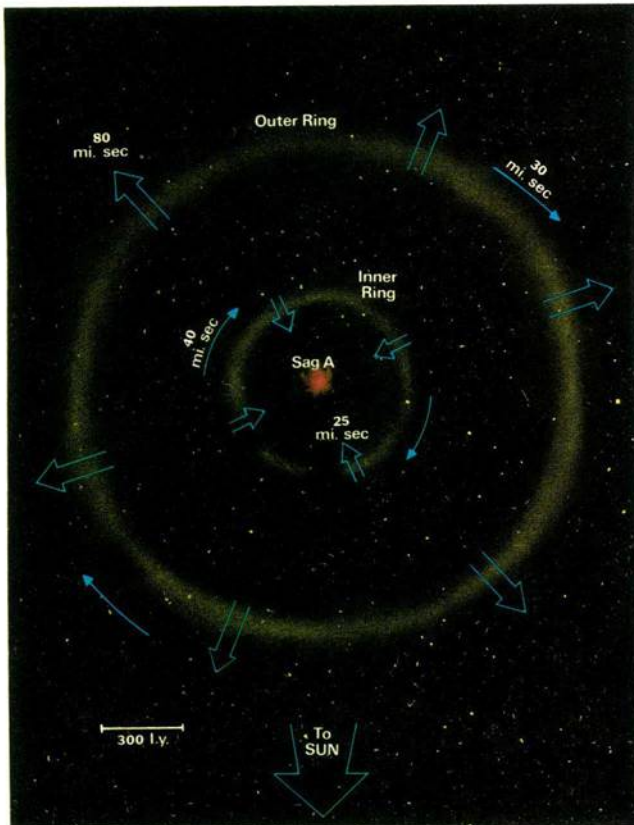


Diagram by Victor Costanzo

This diagram of the ring system illustrated on page 35 shows the system's size, thickness and direction of movement. As the outer ring expands into space, the inner ring appears to be falling into the center of the structure — a region of intense radio and infrared energy called Sagittarius A. Two vast clouds of molecules inhabit the very gaseous inner ring.

remarkable, Sagittarius B2, contains many of the molecules recently discovered in space.

Radio observations of interstellar molecules not only reveal the cloud in Sagittarius B2, but also show that some molecules such as formaldehyde, carbon monoxide and hydroxyl are spread throughout the galactic center region. The direction and distance of the emitting regions provides a clearer picture of what is happening in the nuclear regions of the galaxy just outside the inner concentration of stars and dust.

Apparently there are two doughnut shaped dust clouds ringing the galactic center. An outer ring of molecular material, probably consisting of many individual clouds, has a 1,600 light-year diameter. Containing the equivalent of a hundred million suns, this ring is expanding at 260,000 m.p.h. and rotating at 110,000 m.p.h. Inside that main mole-

The route to the galactic center is far too cluttered by stars and dust for astronomers to ever visually see what is actually occurring there (evident in this photograph of the Milky Way in Sagittarius). But a radio map overlaid on that region shows the location and angular size of the structures at the galactic nucleus. The radio plot actually represents an edge-on view of the ring system depicted on page 35. The photo is a 15 minute guided exposure on Tri-X film taken through a 50mm f/1.8 lens from Las Campanas Observatory, Chile.

Photograph by Chris Smith

National Radio Astronomy Observatory Map

cular ring is an 800 light-year diameter ring, containing hydroxyl and formaldehyde. Also rotating at 110,000 m.p.h., this inner ring is falling in toward the galactic center at 90,000 m.p.h. — indicating the major explosion has ceased.

The expanding ring must have been produced by an explosion while the inner ring is material affected by the outward moving shock wave. Such shock waves could possibly trigger the formation of stars. Vast quantities of molecules may be created in the clouds of gas and dust trapped within the shock wave.

Observations of the radio signals at 21cm wavelength (the characteristic signal of interstellar hydrogen) shows that these molecular doughnuts lie inside a rapidly rotating disk of hydrogen gas. Some regions of this hydrogen are also expanding away from the galaxy's center, implying that an explosive event — occurring about 10 million years ago — initially ejected matter outward at 1.3 million m.p.h. Today astronomers are puzzled as to why this disk of matter still exists following such an incredible explosion, and are even more mystified as to what initially triggered the blast.

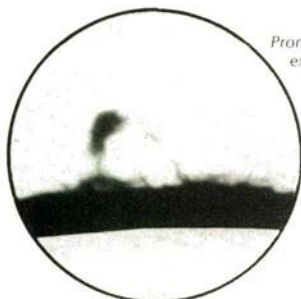
Moving farther outward from the center, additional evidence for the explosion comes from observing the spiral arm structure of our galaxy in the region just outside the galactic nucleus. Radio data reveal a distinct spiral arm on our side of the galactic center moving away from the center at 120,000 m.p.h., and another arm on the far side of the center moving outward at 160,000 m.p.h. Only an explosion initially ejecting two large blobs of matter in nearly opposite directions (at a small angle to the Milky Way so as not to destroy the central disk) can explain the motions. These blobs were subsequently drawn out to form two spiral-arm-like structures. This structuring is similar to the appearance of many radio galaxies that are double sources.

There are also a number of X-ray sources in the direction of the galactic center, but none have been located accurately enough to suggest that they are precisely at the center of the Milky Way.

There has been speculation that a giant black hole — fueled by the nucleus' high density of stars — might be the power plant behind such a colossal explosion. Although observations do not rule out such a beast, so far a black hole of any size is not required to explain the present data.

Uncovering what is happening at the Milky Way's center ranks as one of modern astronomy's most exciting detective hunts. At last we are beginning to fit together many tenuous pieces of evidence into a picture of the hub of our island universe. No doubt this present portrait will be changing in the coming years. But it is unlikely that any new surprises lying just around the corner will force us into rejecting the basic concepts of today's models. 🐼

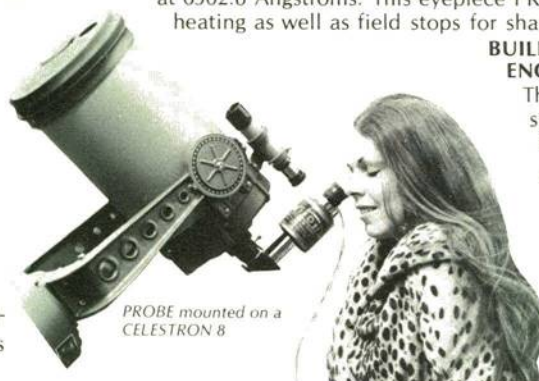
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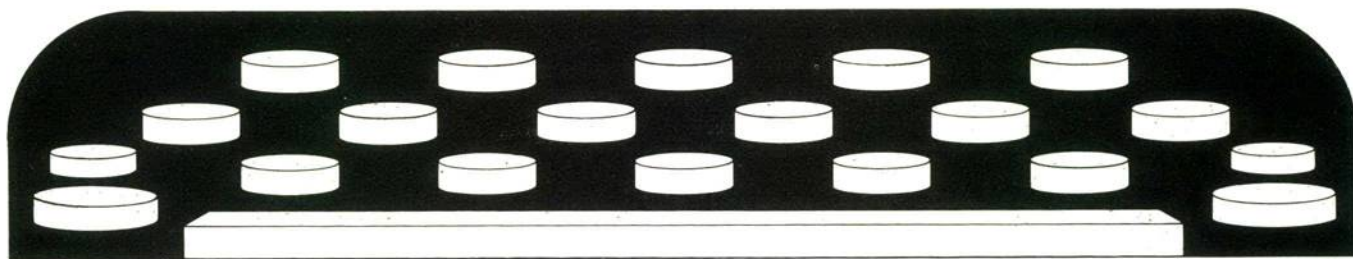
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More on the Zeta Reticuli Incident Editor's Preface

The lead article in the December 1974 issue of *ASTRONOMY*, entitled "The Zeta Reticuli Incident", centered on interpretation of a map allegedly seen inside an extraterrestrial spacecraft. The intent of the article was to expose to our readers a rare instance where astronomical techniques have been used to analyze a key element in a so-called "close encounter" UFO incident. While not claiming that the analysis of the map was proof of a visit by extra-terrestrials, we feel the astronomical aspects of the case are sufficiently intriguing to warrant wide dissemination and further study.

The following notes contain detailed follow-up commentary and information directly related to that article. More will appear next month.

Pattern Recognition and Zeta Reticuli by

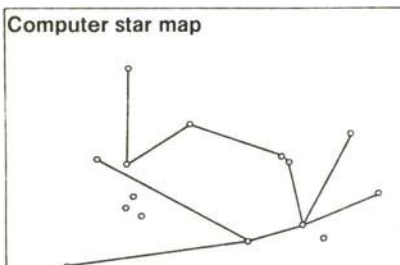
Steven Soter and Carl Sagan

"The Zeta Reticuli Incident" is very provocative. It claims that a map, allegedly shown on board a landed extraterrestrial spacecraft to Betty Hill in 1961, later drawn by her from memory and published in 1966, corresponds well to similar maps of the closest stars resembling the sun based on stellar positions in the 1969 *Gliese Catalog of Nearby Stars*. The comparison maps were made by Marjorie Fish using a three dimensional physical model and later by a group of Ohio State University students using a presumably more accurate (i.e., less subjective) computer generated projection. The argument rests on how well the maps agree and on the statistical significance of the comparison.

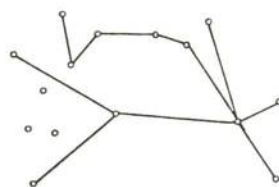
Figure 1 shows the Hill map (center) and the Ohio State computer map (top) with connecting lines as given in the *ASTRONOMY* article. The inclusion of these lines (said to represent trade or navigation routes) to establish a resemblance between the maps is what a lawyer would call "leading the witness". We could just as well have drawn lines as in the bottom of Figure 1 to lead the other way. A less biased comparison of the two data sets, without connecting lines as in Figure 2, shows little similarity. Any residual

resemblance is enhanced by there being the same number of points in each map, and can be accounted for by the manner in which these points were selected.

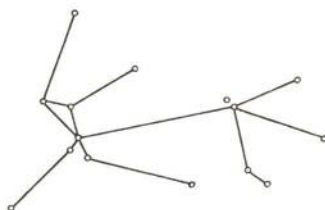
①



Hill map



Computer star map



The computer star map includes the sun and 14 stars selected from a list of the 46 nearest stars similar to the sun, derived from the *Gliese catalog*. It is not clear what criteria were used to select precisely these 14 stars from the list, other than the desire to find a resemblance to the Hill map. However, we can always pick and choose from a large random data set some subset that resembles a preconceived pattern. If we are free also to select the vantage point (from all possible directions for viewing the projection of a three dimensional pattern), it is a simple matter to optimize the desired resemblance. Of course such a resemblance in the case of selection from a random set is a contrivance

— an example of the statistical fallacy known as "the enumeration of favorable circumstances".

The presence of such a fallacy in this case appears even more likely when we examine the original Hill drawing, published in *The Interrupted Journey* by John Fuller. In addition to the prominent points that Betty Hill connected by lines, her map also includes a number of apparently random dots scattered about — evidently to represent the presence of background stars but not meant to suggest actual positions. However, three of these dots appear in the version of the Hill map used in the comparison (Figure 1), while the others are absent. Thus some selection was made even

②

Hill map



Computer star map



from the original Hill map, although not to the same extent as from the *Gliese catalog*. This allows even greater freedom to contrive a resemblance.

Finally, we learn from *The Interrupted Journey* that Betty Hill first thought she saw a remarkable similarity between her UFO star map and a map of the constellation Pegasus

published in the *New York Times* in 1965 to show the position of the quasar CTA-102. How many star maps, derived from the Gliese catalog or elsewhere, have been compared with Betty Hill's before a supposed agreement was found? If we suppress information on such comparisons we also overestimate the significance of the result.

The argument on "The Zeta Reticuli Incident" demonstrates only that if we set out to find a pattern correlation between two nearly random data sets by selecting at will certain elements from each and ignoring others, we will always be successful. The argument cannot serve even to suggest a verification of the Hill story — which in any case is well known to be riddled with internal and external contradictions, and which is amenable to interpretations which do not invoke extraterrestrial intelligence. Those of us concerned with the possibility of extraterrestrial intelligence must take care to demand adequately rigorous standards of evidence. It is all too easy, as the old Chinese proverb says, for the imprisoned maiden to mistake the beating of her own heart for the hoof beats of her rescuer's horse. 🐾

Steven Soter is a research associate working under the advisement of Carl Sagan, director of Cornell University's laboratory for Planetary Studies.

A Reply to Steven Soter
and Carl Sagan

by
Terence Dickinson

The question raised by Steven Soter and Carl Sagan concerning the pattern resemblance of the Hill map and the computer generated projection of the Fish pattern stars is certainly a key question worthy of discussion. Next month two authors will make specific comments on this point.

Briefly, there is more to discounting the Fish interpretation than pattern resemblance. We would have discounted the Fish interpretation immediately on pattern resemblance alone. The fact that *all* the connecting lines join stars in a logical distance progression, and that *all* the stars are solar type stars, is significant. Ms. Fish tried to fit hundreds of other viewpoints and this one was the only one that even marginally fit *and* made sense in three dimensions *and* contained solar type stars. In this context; you could not "have just as well drawn the lines... to lead the other way".

Naturally there was a desire to find a resemblance between a group of nearby stars and the Hill pattern!

That's why Marjorie Fish built six models of the solar neighborhood containing the relative positions of up to 256 nearby stars. The fact that she came up with a pattern that fits as well as it does is a tribute to her perseverance and the accuracy of the models. Stars cannot be moved around "to optimize the desired resemblance". Indeed Marjorie Fish first tried models using nearby stars of other than strictly solar type as defined in the article. She found no resemblances (see following items).

The three triangle dots selected from the background dots in the Hill map were selected because Mrs. Hill said they were more prominent than the other background stars. Such testimony was the basis of the original map so we either accept Mrs. Hill's observations and attempt to analyze them or reject the whole incident. We feel there is sufficient evidence compelling us not to reject the whole incident at this time.

We too are demanding rigorous standards of evidence to establish the reality of extraterrestrial intelligence. If there is even the slightest possibility that the Hills' encounter can provide information about such life, we feel it is worth pursuing. The map is worthy of examination by as many critical minds as possible. 🐾

Is the Fish Interpretation Unique?

by
Robert Sheaffer

The story of Marjorie Fish's attempts at identifying the star patterns sketched by Betty Hill was told in "The Zeta Reticuli Incident" by Terence Dickinson in the December 1974 issue. This pattern of solar type stars unquestionably bears a striking resemblance to the map that Betty Hill says she saw while she was being examined aboard a flying saucer. But how significant is this resemblance? Is there only one pattern of stars which will match the sketch convincingly?

Betty Hill herself discovered an impressive resemblance in a star map published in the *New York Times*. In 1965 a map of the stars of the constellation Pegasus appeared in that newspaper, accompanying the announcement by a Russian radio astronomer (Comrade Sholomitsky) that radio source CTA-102, depicted in the map, may be sending out intelligent radio signals. Intrigued by this remarkable claim, Betty Hill studied the map, and added the corresponding star names to her sketch. As you can see, the Pegasus map — while not exactly like the sketch — is im-

pressively similar. If CTA-102 — appearing near the "globes" in her sketch — was in reality an artificial radio source, that would give the Pegasus map much additional credibility.

However, the case for the artificial origin of quasar CTA-102 soon fell flat. Other scientists were unable to observe these reported strange variations which had caused Sholomitsky to suggest that CTA-102 might be pulsing intelligently.

In 1966, when Marjorie Fish was just beginning her work, Charles W. Atterberg (employed by an aeronautical communications firm in Illinois) also set out to attempt to identify this star pattern.

"I began my search by perusing a star atlas I had on hand," Atterberg explained. "I soon realized that this was a pointless and futile project." Any star pattern useful for interstellar navigation, he reasoned, would not be Earth-centered as are the familiar constellation figures. Thus Atterberg began to look in three dimensions for a pattern of stars that would approximate the Hill sketch.

Working from a list of the nearest stars, Atterberg "began plotting these stars as they would be seen from various directions. I did this by drawing the celestial sphere; by knowing the distance and celestial position of a star, I would draw a straight line penetrating the sphere at a known position, and measure out to the distance of the star.... It at first took me hours to plot this out from any one particular direction."

When plotting the stars as seen from a position indefinitely far away on the celestial equator at 17 hours right ascension, Atterberg found a pattern of stars conspicuously similar to the Hill sketch. After much work he refined this position to 17 hours 30 minutes right ascension, -10 degrees declination. The resulting map resembles the Hill sketch even more strongly than does the Fish map, and it contains a greater number of stars. Furthermore, all of the stars depicted in the Atterberg map lie within 18.2 light-years of the sun. The Fish map reaches out 53 light-years, where our knowledge of stellar distances is much less certain.

Carl Sagan states in *Intelligent Life in the Universe* that, excluding multiple star systems, "the three nearest stars of potential biological interest are Epsilon Eridani, Epsilon Indi and Tau Ceti." These three stars form the heart of the Atterberg map, defining the two spheres in the very center of the heavy lines that supposedly represent the major "trade routes" of the "UFO-nauts". Epsilon Eridani

and Tau Ceti were the two stars listened to by Project Ozma, the pioneering radio search for intelligent civilization in space.

Other heavy lines connect the spheres with the sun, which we *know* has at least one habitable planet. Thinner lines, supposedly representing places visited less frequently, connect with Groombridge 1618, Groombridge 34, 61 Cygni and Sigma Draconis, which are designated as stars "that could have habitable planets" in Stephen H. Dole's Rand Corporation study, **Habitable Planets for Man**. Of the 11 stars (not counting the sun) that have allegedly been visited by the aliens, seven of them appear on Dole's list. Three of the four stars which are not included are stopping points on the trip to Sigma Draconis, which Dole considered to have even better prospects than Epsilon Eridani or Epsilon Indi for harboring a habitable planet.

Another remarkable aspect of the Atterberg map is the fact that its orientation, unlike the Fish map, is not purely arbitrary. Gould's belt — a concentration of the sky's brightest stars — is exactly perpendicular to the plane of the Atterberg map. Furthermore, it is vertical in orientation; it does not cut obliquely across the map, but runs exactly up and down. A third curious coincidence: The south pole of the Atterberg map points toward the brightest part of Gould's belt, in the constellation Carina. The bright stars comprising Gould's belt might well serve as a useful reference frame for interstellar travelers, and it is quite plausible that they might base a navigational coordinate system upon it.

No other map interpreting the Hill sketch offers any rationale for its choice of perspectives. The problem with trying to interpret Betty Hill's sketch is that it simply fits too many star patterns. Three such patterns have been documented to date. How many more exist undiscovered?

Robert Sheaffer is a computer systems programmer currently working at NASA's Goddard Space Flight Center in Greenbelt, Md.

A Reply to Robert Sheaffer

by
Marjorie Fish

Basically, Robert Sheaffer's contention is that at least three patterns can be found that are similar to Betty Hill's map, and therefore, more such interpretations are likely. If one stipulates that any stars from any vantage point can be used, then I agree that many patterns can be found similar to

the map. However, if one uses restrictions on the type of stars, according to their probability of having planets and also on the logic of the apparent travel paths, then it is much more difficult. The three maps were: (1) Betty Hill's interpretation of the constellation Pegasus as being similar to her map, (2) Charles Atterberg's work, and (3) my work.

When I started the search, I made a number of restrictions including:

1) The sun had to be part of the pattern with a line connected to it, since the leader of the aliens indicated this to Betty.

2) Since they came to our solar system, they should also be interested in solar type stars (single main sequence G, probably also late single main sequence F and early single main sequence K). These stars should not be bypassed if they are in the same general volume of space.

3) Since there are a number of the above stars relatively near the sun and the pattern shows only 12 stars, the pattern would have to be relatively close to us (or else they would be bypassing sunlike stars, which is illogical).

4) The travel pattern itself should be logical. That is, they would not zip out 300 light-years, back to 10 light-years, then out 1,000, etc. The moves should make a logical progression.

5) Large young main sequence stars (O, B, A, early F) which are unlikely to have planets and/or life would not be likely to be visited.

6) Stars off the main sequence with the possible exception of those just starting off the main sequence would probably be avoided as they are unsuitable for life and, due to their variability, could be dangerous.

7) If they go to one star of a given type, it shows interest in that type star — so they should go to other stars of that type if they are in the same volume of space. An exception to this might be the closest stars to the base star, which they might investigate out of curiosity in the early stages of stellar travel. For example, they would not be likely to bypass five red dwarfs to stop at the sixth, if all six were approximately equal in size, spectra, singleness or multiplicity, etc. Or, if they go to one close G double, they would probably go to other close G doubles.

8) The base star or stars is one or both of the large circles with the lines radiating from it.

9) One or both of the base stars should be suitable for life — F8 to K5 using the lowest limits given by exobiologists, or more likely, K1 given by Dole.

10) Because the base stars are represented as such large circles, they are either intrinsically bigger or brighter than the rest or they are closer to the map's surface (the viewer) than the rest — probably the latter. This was later confirmed by Betty Hill.

Mrs. Hill's interpretation of Pegasus disregards *all* of these criteria.

Atterberg's work is well done. His positioning of the stars is accurate. He complies with criteria 1, 2, 3, 5, 6 and 8; fairly well with 4; less well with 9, and breaks down on 7 and 10. I will discuss the last three of Atterberg's differences with my basic criteria in the following paragraphs:

Relative to point 9, his base stars are Epsilon Indi and Epsilon Eridani, both of which are near the lower limit for life bearing planets — according to most exobiologists — and not nearly as suitable as Zeta 1 and 2 Reticuli

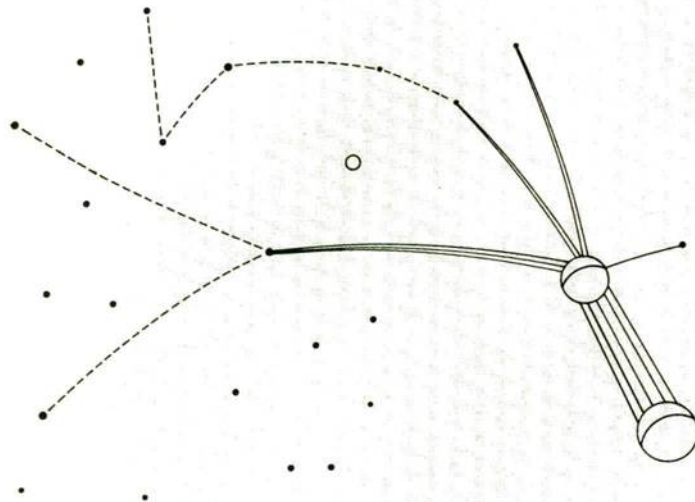
Concerning point 7, I had ruled out the red dwarfs fairly early because there were so many of them and there were only 12 lined points on the Hill map. If one used red dwarfs in logical consecutive order, all the lines were used up before the sun was reached. Atterberg used red dwarfs for *some* of his points to make the map resemble Betty Hill's but he *bypassed* equally good similar red dwarfs to reach them. If they were interested in red dwarfs, there should have been lines going to Gliese 65 (Luyten 76208) which lies near Tau Ceti and about the same distance from Epsilon Eridani as Tau Ceti, and Gliese 866 (Luyten 789-6) which is closer to Tau Ceti than the sun. Gliese 1 (CD-37 15492) and Gliese 887 (CD-36 15693) are relatively close to Epsilon Indi. These should have been explored first before red dwarfs farther away.

Red dwarfs Gliese 406 (Wolf 359) and Gliese 411 (BD + 36 2147) were bypassed to reach Groombridge 1618 and Ross 128 from the sun. Barnard's star would be the most logical first stop out from the sun, if one were to stop at red dwarfs, as it is the closest single M and is known to have planets.

Since Atterberg's pattern stars include a number of relatively close doubles (61 Cygni, Struve 2398, Groombridge 34 and Kruger 60), there should also be a line to Alpha Centauri — but there is not.

Relating to point 10, Atterberg's base stars are not the largest or brightest of his pattern stars. The sun, Tau Ceti, and Sigma Draconis are brighter. Nor are they closer to the viewer. The sun and 61 Cygni are much closer to the viewer than Epsilon Eridani. The whole orientation feels wrong because the base stars are away from the viewer and movement is

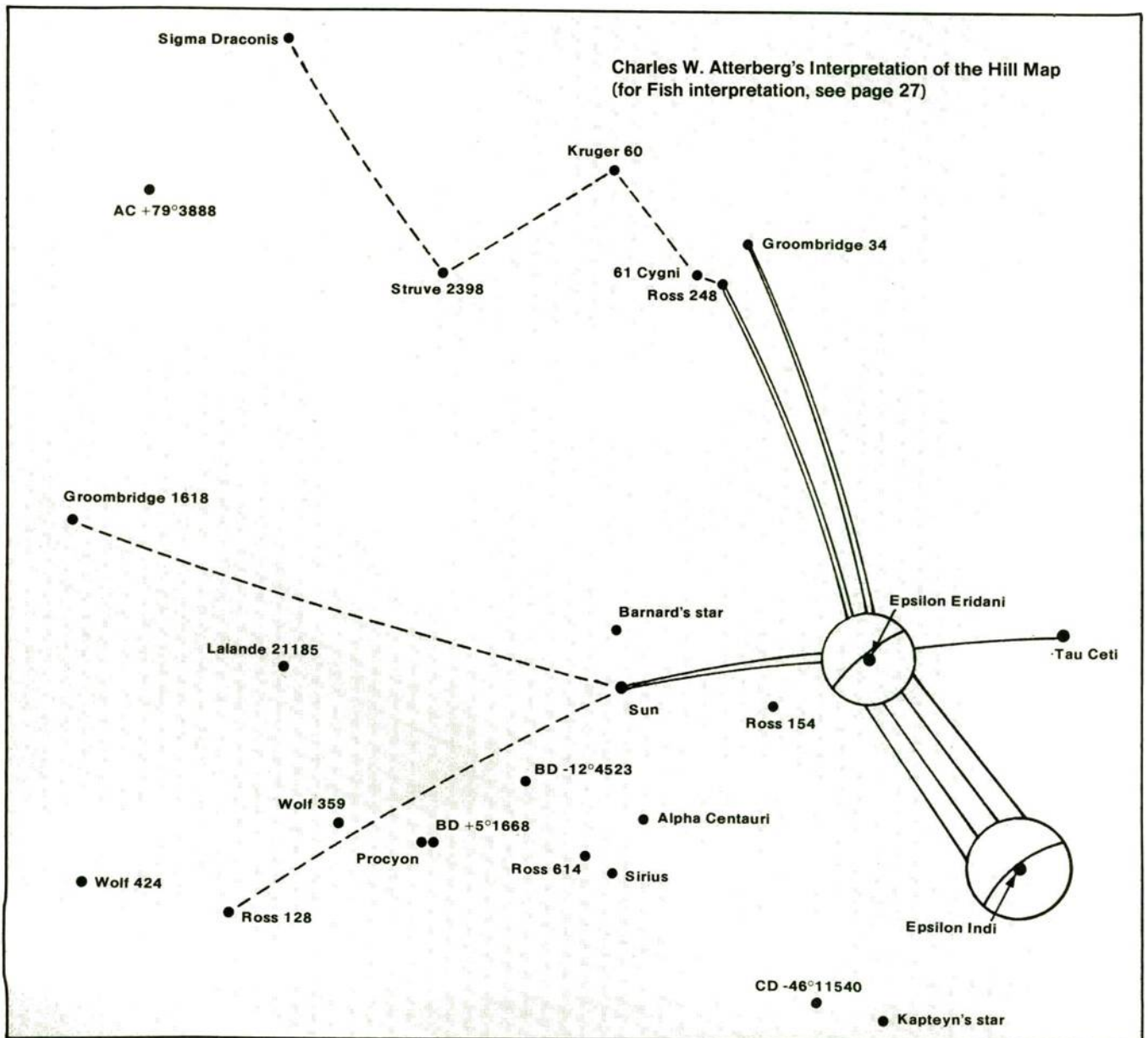
Betty Hill's Original Sketch



along the lines toward the viewer. (Betty Hill told me that she tried to show the size and depth of the stars by the relative size of the circles she drew. This and the fact that the map was alleged to be 3-D did not come out in *Interrupted Journey*, so Atterberg would not have known that.)

Sheaffer notes that seven of Atterberg's pattern stars appear on Dole's list as stars that could have habitable planets. These stars are Groombridge 1618 (Gliese 380, BD + 50 1725), Groombridge 34 (Gliese 15, BD + 43 44), 61 Cygni, Sigma Draconis, Tau Ceti, Epsilon Eridani and Epsilon Indi. Of these seven, only Epsilon Eridani, Tau Ceti and Sigma Draconis are above Dole's absolute magnitude minimum. The others are listed in a table in his book *Habitable Planets for Man*, but with the designation: "Probability of habitable planet very small; less than 0.001." Epsilon Eridani was discussed earlier. Sigma

Charles W. Atterberg's Interpretation of the Hill Map
(for Fish interpretation, see page 27)



Draconis appears good but is listed as a probable variable in Dorrit Hoffleit's *Catalogue of Bright Stars*. Variability great enough to be noticed from Earth at Sigma Draconis' distance would cause problems for life on its planets. This leaves Tau Ceti which is one of my pattern stars also.

Another point Sheaffer made was that orientation of my map was arbitrary compared to Atterberg's map's orientation with Gould's belt. One of my first questions to Betty Hill was,

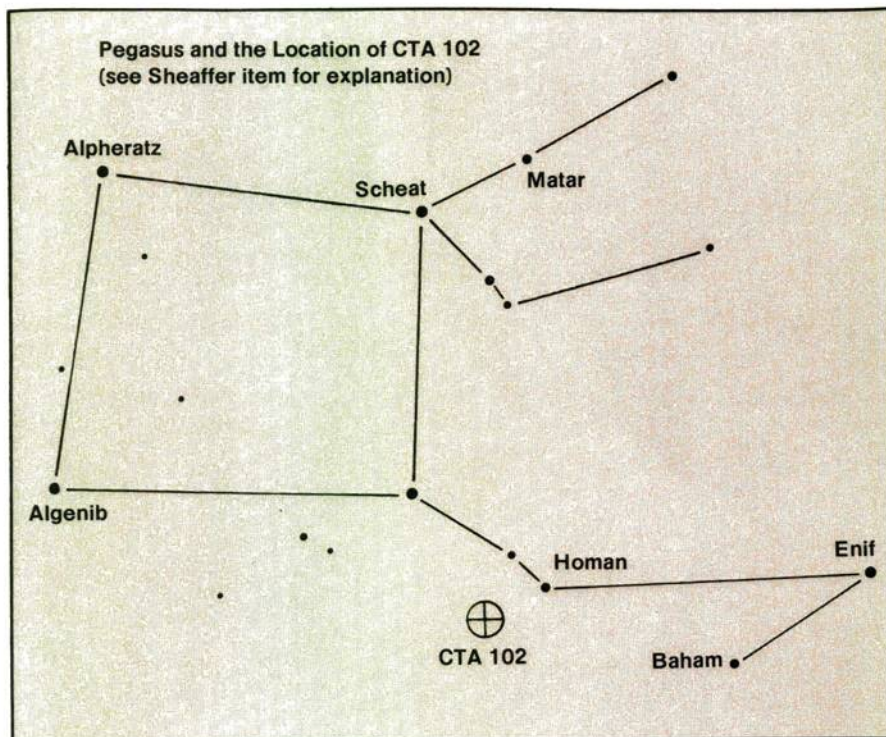
"Did any bright band or concentration of stars show?" This would establish the galactic plane and the map's orientation, as well as indicate it was not just a local map. But there was none indicating that if the map was valid it was probably just a local one.

The plane of the face of my model map is not random, as Sheaffer indicated. It has intrinsic value for the viewer since many of the pattern stars form a plane at this viewing angle. The value to the viewer is that

these stars have their widest viewing separation at that angle, and their relative distances are much more easily comprehended.

My final interpretation of the map was the only one I could find where all the restrictions outlined above were met. The fact that only stars most suitable for Earthlike planets remained and filled the pattern seems significant.

Marjorie Fish is a research assistant at Oak Ridge National Laboratory in Tennessee.



Zeta Reticuli — A Rare System

by

Jeffrey L. Kretsch

Zeta Reticuli is a unique system in the solar neighborhood — a wide physically associated pair of stars almost exactly like the sun. After searching through a list of stars selected from the Gliese catalog on the basis of life criteria, only one other pair within a separation of even 0.3 light-years could be found. (This pair — Gliese 201 and Gliese 202, a K5e and F8Ve pair separated by 0.15 light-years — is currently being investigated.) Zeta Reticuli is indeed a rare case.

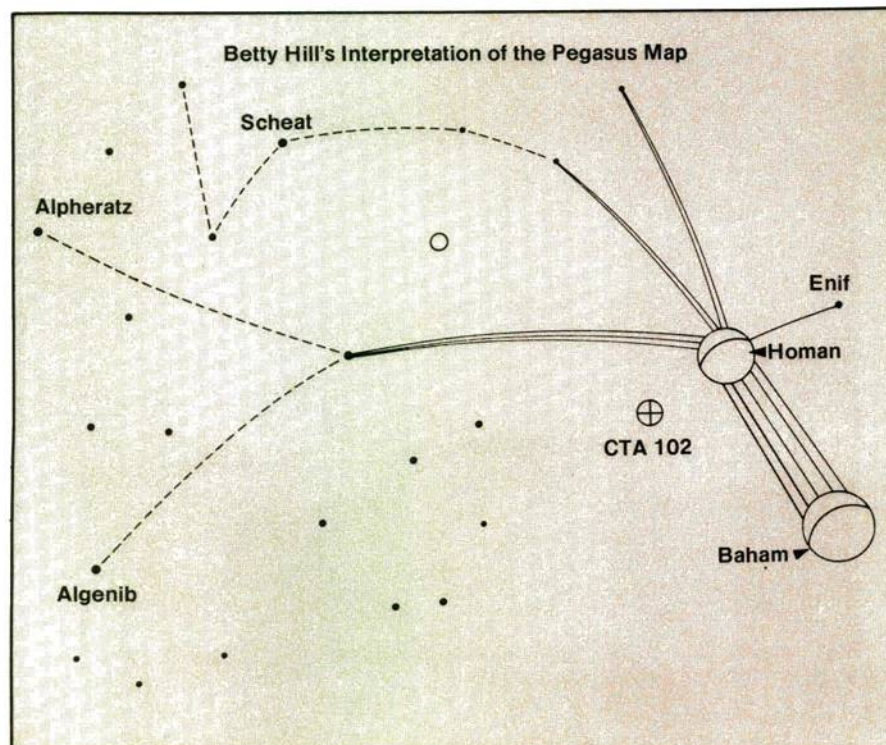
Based on the Fish interpretation of the Hill map, the Zeta Reticuli pair forms the base of the pattern. If the other stars in the pattern fit, it is a remarkable association with a rare star system.

In order to deal with this problem, I decided to compute the three-dimensional positions of the stars and construct a three-dimensional model showing these stars' positions.

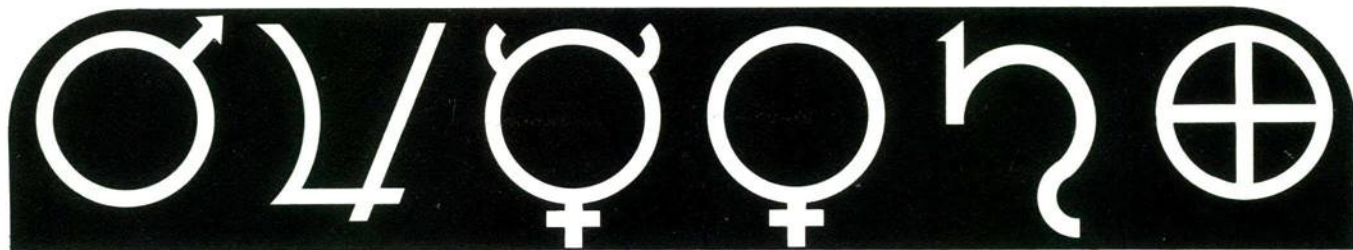
Speaking quantitatively, I discovered the two patterns are certainly not an exact match. However, if one considers the question of match from the standpoint of how the Hill pattern was made as opposed to the derived pattern's means of reproduction, the quantitative data may not be a complete means of determining whether the two patterns "match" or not. For example, the Hill pattern was drawn freehand — so one would have to determine how much allowance one must give for differences in quantitative data. In such areas, I am not qualified to give an opinion. However, because the map was drawn freehand from memory, the fact that the resemblance between the Fish map and the Hill map is a striking one should be considered.

In my work I was able to verify the findings of Marjorie Fish in terms of the astronomy used.

Jeffrey L. Kretsch is an astronomy student at Northwestern University.







SKY ALMANAC

Venus Reaches Greatest Brilliance

As celestial mechanics would have it, these warm evenings are not favorable for planet watching. Determined skywatchers will have to stay up into the early morning hours before glimpsing Jupiter and Mars overhead (the two worlds are only about 15 degrees apart this month). Venus offers some consolation — it will reach its greatest annual evening brilliancy toward the end of the month.

Venus

The first and exceptionally bright gem of the evening, Venus moves increasingly lower in the western sky until by month's end it is visible for

The exceptionally dark lunar eclipse of May 24, 1975 is captured here — along with the adjacent stars of Scorpius — using a 300mm f/5.5 telephoto lens. The five minute guided exposure on Fujichrome R-100 was taken from California's Malibu Mountains. A full eclipse report with photos will be in next month's issue.

Photograph by Dennis Stayer

Satellite Shadows On Jupiter

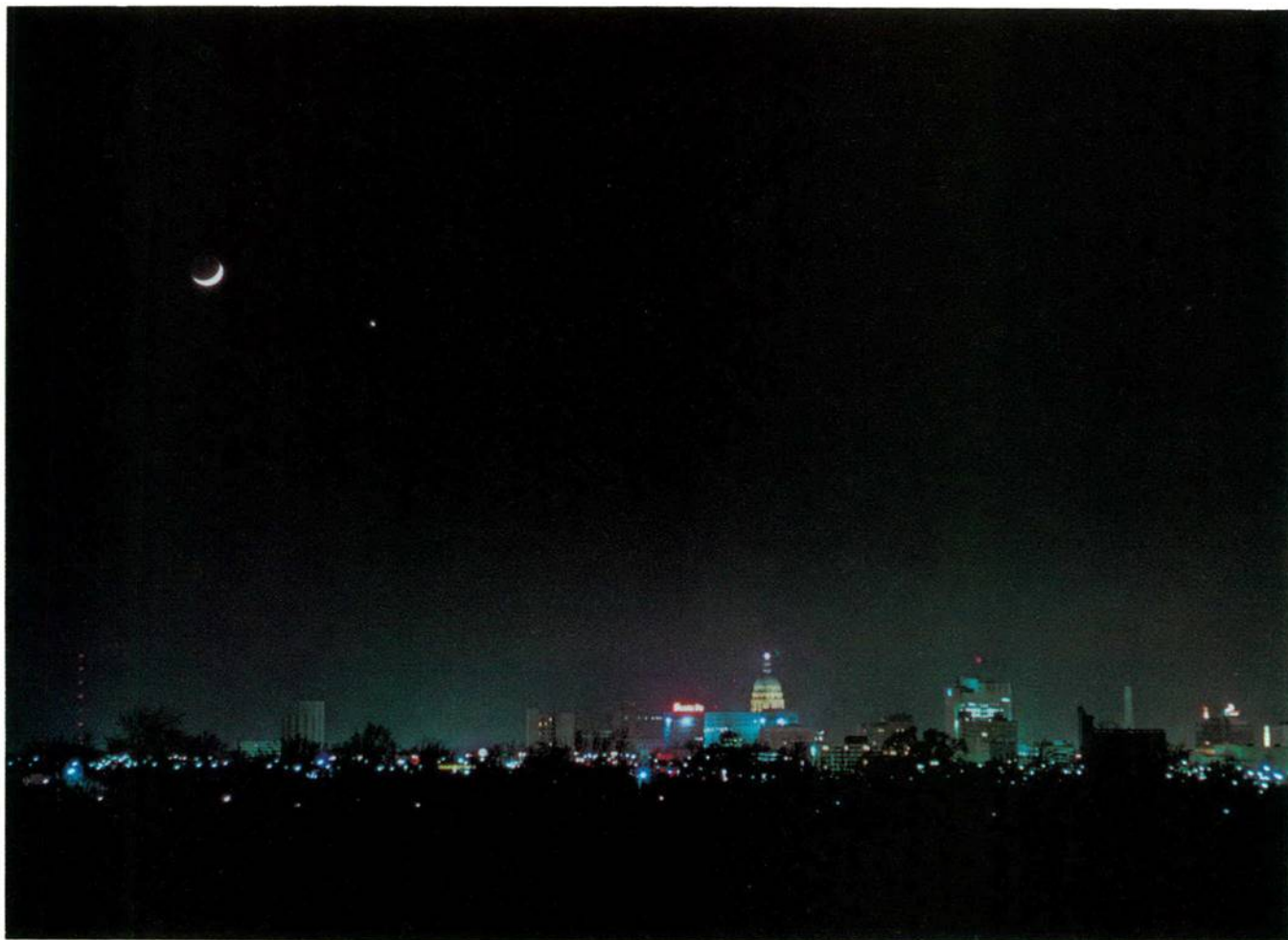
Date	Satellite	Transit Begins (EDT)	Transit Ends (EDT)
July 2	2	2:40 a.m.	5:24 a.m.
	1	2:19 a.m.	4:30 a.m.
9	1	4:13 a.m.	6:23 a.m.
	2	5:17 a.m.	8:01 a.m.
16	1	6:07 a.m.	8:17 a.m.
18	1	12:35 a.m.	2:45 a.m.
25	1	2:29 a.m.	4:39 a.m.
26-27	2	11:51 p.m.	2:34 a.m.
29	3	12:53 a.m.	3:36 a.m.

1 = Io

2 = Europa

3 = Ganymede

4 = Callisto



Photograph by Rick Schmidt

Venus and the first quarter moon hover above downtown Topeka, Ks. on a mid-April evening. A Nikkormat equipped

with a Nikkor 85mm lens captured the celestial pair in a 10 second f/1.8 exposure on Kodachrome II.

only one half hour following sunset. But, as the month progresses, Venus also grows brighter — until July 21, when it radiates at -4.2 magnitude. Although our sister planet sometimes reaches -4.4 magnitude, -4.2 is the brightest it appears for any evening in 1975. Early in October, Venus returns for a -4.3 magnitude encore in the early *morning* sky.

Just as the moon is brightest when it appears as a full disk, you might think that Venus is a full phase on the 21st. In reality, a small telescope will reveal that the planet appears crescent shaped, with only 26 percent of its illuminated surface visible. When Venus does appear as a full disk, it is on the far side of the sun; thus, the planet is then at its greatest distance from Earth. This cancels out whatever added brightness Venus' fully illuminated disk would offer.

On the 1st, Venus will be 55 million miles away, and that distance will shrink to 32 million miles by month's end. The planet's apparent diameter increases from 28 to 43 seconds of arc during July while its phase decreases from 41 to 22 percent illuminated. Because of its large apparent size,

its crescent shape should easily be seen in the smallest telescopes.

Jupiter

Not rising above the eastern horizon until around midnight, Jupiter dominates July's early morning sky. Located in the constellation Pisces, the giant planet glistens at -2.0 magnitude for most of the month. As Earth's orbit continues to carry us closer to Jupiter, its apparent equatorial diameter increases from 38.9 seconds of arc to 42.5 seconds on the 31st.

Astronomy enthusiasts should now start warming up for observing one of the solar system's most spectacular members. Jupiter promises to be an increasingly prominent object in the coming months. Outside of Jupiter's beautiful cloud bands and Great Red Spot, a miniature "solar system" of the four Galilean moons is especially intriguing to follow.

With this issue we are resuming the table of daily positions of the four largest moons: Io, Europa, Callisto and Ganymede. Also included is a listing of satellite transits across Jupiter's disk. It's a special challenge to track the tiny black dot

of a satellite's shadow skimming across Jupiter's cloudtops.

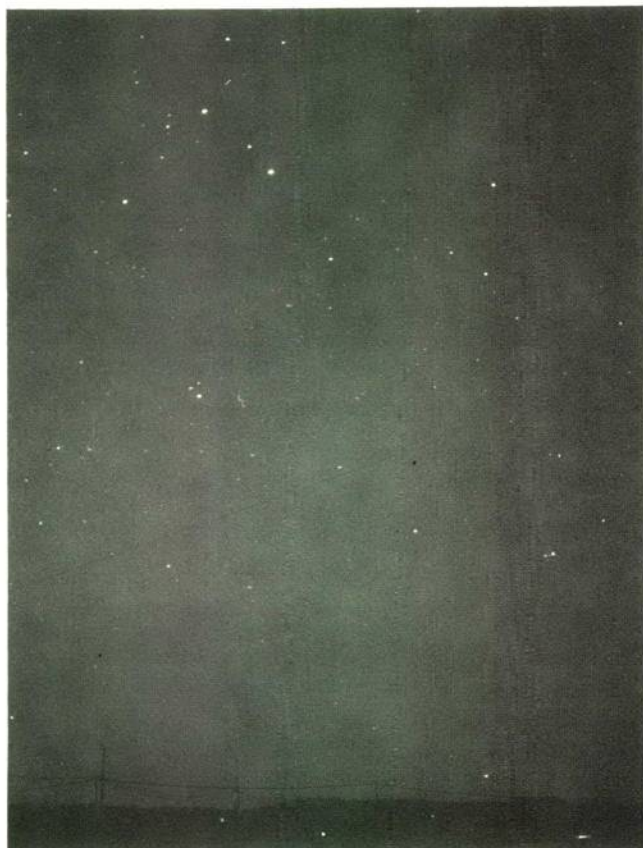
Mars

The red planet follows Jupiter by an hour this month. But don't worry about confusing the two worlds: At +0.6 magnitude, Mars is now more than six times fainter than Jupiter. Nevertheless, the red planet retains some prominence while occupying the small and inconspicuous constellation Aries.

During July, Mars' disk grows from 6.8 seconds of arc in diameter to 7.6 seconds, as Earth reduces its distance to Mars by 14 million miles (placing it at a range of 113 million miles by July 31). The red planet is still too far away for any details of its surface to be seen in moderate telescopes.

Mercury

For the first few days in July, Mercury is visible as a +0.8 magnitude object low in the eastern horizon, preceding sunrise by about one hour. Then 70 million miles away, Mercury's eight second of arc diameter disk exhibits a 30 percent phase. By the end of the month, the speedy planet almost doubles its distance from Earth to 120 million



Photograph by Michael C. Cheek

The brilliant southern hemisphere star Canopus peeks above the southern horizon in this photograph from Greensboro, N.C. Greensboro lies just one degree of latitude south of the northern hemisphere boundary — 37 degrees north latitude — where -0.9 magnitude Canopus never rises above the horizon. This 20 second f/1.4 exposure was taken Feb. 26, 1975 using a Minolta SRT-102 camera equipped with a standard 50mm Rokkor lens.

SATELLITES OF JUPITER					
JULY					
1	43102	• • • • •	16	43012	• • • • •
2	34102	• • • • •	17	4320	• • • • •
3	3201	• • • • •	18	43210	• • • • •
4	1024	• • • • •	19	4032	• • • • •
5	01234	• • • • •	20	1203	• • • • •
6	12034	• • • • •	21	20143	• • • • •
7	20134	• • • • •	22	1024	• • • • •
8	13024	• • • • •	23	30124	• • • • •
9	30124	• • • • •	24	32104	• • • • •
10	3204	• • • • •	25	3204	• • • • •
11	1304	• • • • •	26	0324	• • • • •
12	40132	• • • • •	27	2043	• • • • •
13	41203	• • • • •	28	20413	• • • • •
14	42013	• • • • •	29	41023	• • • • •
15	41302	• • • • •	30	43012	• • • • •
			31	43210	• • • • •

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 2 a.m. (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0=Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

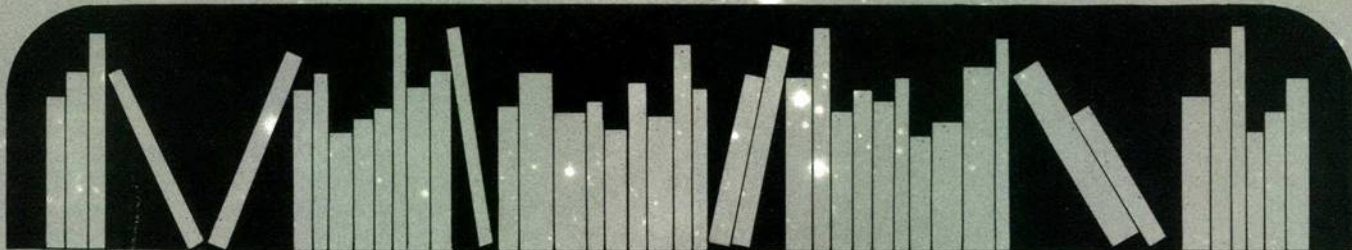
miles — but before mid-July, Mercury moves too close to the sun to be easily observed.

Saturn

Unfortunately, the ringed planet is not visible these summer nights. Now in the constellation Gemini and too close to the sun to be seen, Saturn reaches conjunction with the sun on July 15. On this date, the planet will be 939,404,790 miles from Earth — the greatest separation between the two worlds for this year.

Meteors

Stretching from mid-July to mid-August, the Delta Aquarid shower peaks on the morning of July 29. Radiating from the vicinity of Aquarius' urn, up to 35 meteors per hour have been reported. But don't hope for such a spectacle this time around. The gibbous moon sitting in neighboring Pisces will wash out the Delta Aquarids this year. ☾



ASTRONOMY REVIEWS

Life Beyond Earth and the Mind of Man

edited by RICHARD BERENDZEN

106 pages, paperback, \$1.25*
U.S. Government Printing Office (1973)

A symposium to explore the implications of intelligent life elsewhere in the universe, and the effects of contact with them upon human civilization, was held in Boston in November 1972. A collection of scientists, scholars and theologians spent a few hours describing their own ideas, questioning each other, and answering queries from the audience. This booklet is a slightly abridged transcript of that symposium.

The keynote speaker was noted astronomer Carl Sagan, whose far-reaching ideas and facility of expressing them should be well-known to readers of this magazine. Sagan briefly sketched the reasons for thinking that listening for extraterrestrial radio broadcasts can be worthwhile. He also related a few amusing anecdotes concerning the Pioneer 10 message plaque intended as a coded greeting card to anyone who ever picks it up between the stars.

Nobel Prize winning biologist George Wald expressed his concern that contact with superior civilizations, and the acquisition from them of the solutions to all of mankind's medical, technological and cultural problems, might break mankind's inquisitive spirit. But anthropologist Ashley Montagu didn't think much about this human trait, or for that matter any other contemporary human characteristic. When asked by a listener whether men should ever try to live off Earth on some other world, Montagu proclaimed that it would be "absolutely undesirable" at least until "we have learned to solve our problems on this Earth."

Theologian Krister Stendahl discussed the implications of other intelligent life on religion and the concept of God. He pointed out that, if knowledge may not be the basis for power, at least ignorance is often the basis of fear, and that increasing knowledge "is not only an interesting thing but is also a road toward learning...what not to fear." Philip Morrison, physicist and philosopher of science, points out the

ways that a message from outer space might affect human life. Such communications, which for centuries will be only one way, will probably be the only contact Earth ever has with alien civilizations. The distances between the stars, Morrison maintains, rule out all but the once per millennium "ceremonial visit".

Moderator Berendzen ends the book with the observation that these interstellar signals "quite possibly are passing through this room and through our very bodies. If we only knew exactly where and how to look!"

The contemporary debate and discussion of the implications of extraterrestrial intelligence is also passing through rooms and bodies around this planet. This book is one view of that exciting subject.

*Stock number NASA-SP-328; for sale by Superintendent of Documents, Washington, D.C. 20402.

Communication With Extraterrestrial Intelligence (CETI)

edited by CARL SAGAN

428 pages, hardcover, \$10.00
MIT Press (1973)

Thirty years ago, most astronomers felt that any discussion of contacting life beyond Earth belonged in comic books. Since then the probability of contact with extraterrestrial life has become the subject of serious scientific research — thanks to advances in astrophysics and biochemistry. As confidence about life in space continues blossoming, the key question has now become: *When will we contact alien civilizations?*

In 1972, Soviet and American scientists from a wide range of disciplines met in the USSR to consider this profound question. Stenotypists faithfully logged proceedings as some meetings, so engrossed in discussion, ran far into the night. Now, at the initiative of Cornell University's Carl Sagan, the

full conference is available in *Communication With Extraterrestrial Intelligence (CETI)*.

The caliber of the participants and the broad spectrum of topics they discuss will likely make CETI a valuable sourcebook on extraterrestrial life for years to come. One-third of the papers presented methodically review the long list of arguments for the existence of intelligent life in space. Another set of chapters investigates communication channels for contacting life — ranging from radio to the hypothetical tachyons (particles that only travel faster than light). These discussions also consider the tantalizing possibility that grand-scale alien engineering activities may cause observable space phenomena that we've just been too dumb to recognize. Sprinkled throughout the conference are such philosophical discussions as the consequences of contact, message contents, and the lifetime of technological societies. For example, do such civilizations destroy themselves by nuclear warfare or do their lifetimes stretch into millions of years?

To appreciate CETI, readers should keep in mind that it is not written for a general audience; it is simply a record of scientists talking to other scientists. For the casual reader this means that things can get technically tedious at times — especially in chapters digging into the nitty-gritty of modes of communication. Patience is also required since the subject matter involves a broad range of sciences — from sociology to organic chemistry.

But the often candid, lively discussions by the conference's participants more than makes up for their occasional scientific stuffiness. Even the most casual of readers will be fascinated by the unique insights about man that the meeting stimulates from its scientists.

Those weaned on sensationalistic, pseudoscientific paperbacks popularizing the possibility of life beyond Earth may be turned off by CETI's strictly scientific approach. We hope not. CETI and its participating scientists may someday help make contact with alien civilizations a reality.

Skylab and the Sun

edited by L. N. WERNER

50 pages, paperback, \$.95*
U.S. Government Printing Office (1973)

Skylab Experiments

63 pages, paperback, \$1.25**
U.S. Government Printing Office (1973)

Anyone seriously interested in solar astronomy from space must read these two handsome NASA booklets. They detail the development and construction of the Skylab ATM (Apollo Telescope Mount), the experiments planned with it, and the organization of auxiliary support activities. They also tell how high school students can conduct similar experiments and obtain real Skylab data for classroom use.

Why study the sun at all? Three distinct arguments explain the motivations and expected payoffs of the Skylab solar astronomy project. First, solar phenomena have a great influence on Earth — aside from being the only reason life exists at all. Magnetic and radio storms, as well as yet little understood effects on the planet's weather, are things people just have to know more about. Second, solar phenomena uniquely illustrate principles of atomic, nuclear and plasma physics, aerodynamics, hydrodynamics and magnetohydrodynamics which must be understood before scientists can learn how to achieve controlled thermonuclear fusion and conquer forever the worsening world-wide energy crisis. Lastly, the sun is a star like innumerable others, and as such holds the key to new theories of stellar structure and evolution — theories which can be extended to billions of other solar systems throughout the universe.

Werner's book is a general background to the study of the sun, providing a basic description of solar energy processes as understood before Skylab. A valuable aspect of this booklet is the detailing of the organization of Skylab and other research efforts into a coordinated observing project. Astronauts and scientists don't just look through telescopes and report what they find. These experiments are often part of a world-wide (or today even solar system-wide) scientific program — planned, charted and coordinated far in advance. These administrative matters are interesting, important and little known.

The book on the experiments themselves (actually part of a seven volume set, whose total price is \$7.05) goes into great detail on the theory and construction of each telescope, the modes of operation, the phenomena to be observed by each, and the types of things to be learned. As mentioned, the book is geared as a teacher's aid for planning high school science activities

associated with different aspects of each telescope. Each section gives details on fascinating experiments which students can carry out.

The results of the Skylab experiments will become available in 1975. These two booklets will give student astronomers an appreciation of how these discoveries were made. Furthermore, similar new experiments will take place on early Space Shuttle flights (an ATM will be one of the first science payloads) in 1980, and continuously thereafter.

Space astronomy is just beginning — and here are two excellent technical introductions for future space astronomers.

*Stock number NASA-1.19:119.
**Stock number NASA EP-110. Both for sale by Superintendent of Documents, Washington, D.C. 20402.

Skylab: A Guidebook

by LELAND BELEW and
ERNST STUHLINGER

245 pages, paperback, \$2.10*
U.S. Government Printing Office (1973)

This would have been a beautiful reference book to have had available during the exciting 1973-74 Skylab mission. Newspaper explanations of the space station's modules, equipment and problems were usually brief, oversimplified and superficial.

But better late than never. Now we have a detailed, well-illustrated and well-written guidebook to the world's first successful space station. (Purists may award that title to the pioneering Russian spacecraft Salyut 1 in 1971. But the module was only visited once, and the crew did not survive the expedition.) In the 12 chapters and 220 photographs, schematics and sketches, we are offered all (if not more than) we have ever wanted to know about how a space station is put together and operated.

Although the Skylab mission is over, and tentative plans for a second flight in 1976 are just about dead, this booklet is still important for a number of reasons. First of all, the scientific results of Skylab are only now being processed, and an in-depth familiarity with the experimental equipment and procedures will help observers to appreciate the discoveries as they are announced. Also, Skylab will be the prototype of the space stations of the 1980s. The precedents which it has set (for example, the use of naval terms like wardroom, bulkhead, head, and galley)

will probably stand for decades or longer.

*Stock number EP-107; for sale by Superintendent of Documents, Washington, D.C. 20402.

Simple Astronomy

by IAIN NICOLSON
illustrated by DON POTTINGER

64 pages, hardcover, \$6.95
Charles Scribner's Sons (1973)

One of the most difficult tasks that can face an astronomy teacher — regardless of the medium of expression involved — is the explanation of some of the concepts of the celestial sphere. Often the teacher finds it easier to impart an understanding of the rotation of the galaxy than the rotation of the moon to a group of students. So the writer who jumps into the topic of elementary celestial sphere astronomy — and has the added audacity to entitle his work *Simple Astronomy* — seriously risks landing in the quicksand of confusion rather than paydirt. Fortunately, Iain Nicolson and Don Pottinger have compiled a book that deals with these difficult matters in a way that can be recommended with few reservations to the novice enthusiast.

Simple Astronomy opens with a chapter entitled "The Moving Sky", which deals with celestial sphere astronomy with a text and graphical partnership that is one of the finest achievements in the literature of the subject. They cover such concepts as seasonal sky changes, the zodiac, sidereal and solar time, and the effect of latitude on the stars visible to the observer with a facility that has seldom been equalled. This chapter is worth the price of the book alone.

Subsequent chapters on the size and measurement of the universe, the solar system, astronomical hardware, the nature of stars and galaxies, and a wrap-up on rockets and satellites all maintain the level of lucid communication established at the outset.

Ironically, this book which features some of the finest graphics in astronomical literature does suffer from an occasional overdose of diagrams. A few pages are needlessly cluttered by diagrams slotted into corners and tucked into paragraphs where the practicalities of publication have reduced them in size to the point of being quite illegible and useless.

But, on the whole, this book lives up to its title's promise — and that makes its occasional problems with layout comparatively easy to overlook.



PHOTOGRAPHY IN ASTRONOMY

Equipment for Guided Astrophotography

by
Leo C. Henzl Jr.

Complete the following statement with the most appropriate response:

In comparison to other types of astrophotography, guided photography through a telescope is: I) easier, II) more difficult, III) more rewarding, IV) more frustrating.

Stuck? No wonder. The veteran deep sky photographer would insist on a fifth choice: *all of the above.*

What distinguishes guided astrophotography from all its brethren types is the photographer's active involvement during the exposure. In lunar and planetary photography — with exposures typically less than 10 seconds — the photographer's role becomes passive once he trips the shutter. His control over the quality of the end product is limited to preparing skillfully beforehand, and shooting many frames while good seeing prevails (see *Photography in Astronomy*, April 1975). Careful preparation is imperative in guided photography too, with particular attention to polar alignment — but more important yet is the photographer's skill in guiding his instrument.

However we choose to regard guided photography, we may be certain of at least one thing: It requires more specialized equipment than other types. Besides the clock driven telescope, SLR

camera body, and miscellaneous fittings employed in serious short exposure photography, we need:

- 1) a means of monitoring a guide star at a magnification substantially greater than that employed for actual shooting — either a separate guide telescope, or an off-axis guiding unit;
- 2) an electronic drive corrector to correct for tracking anomalies that item 1 will disclose, and
- 3) a declination slow motion control — manual or electric — to correct for slight errors in polar alignment, as well as possible flexures in the instrument.

Precision declination controls are included with many telescopes, or are optionally available with others. The main requirements are precision and freedom from backlash. For accurate guiding,

The diaphanous drapery of the Veil nebula, apparently illuminated by the fourth magnitude star 52 Cygni, is a delicate subject for the astrophotographer. The Veil's association with 52 Cygni is illusionary; the star is actually much closer than the nebula. This one hour exposure on cooled emulsion High Speed Ektachrome through a 16 inch home built Newtonian reflector is a portion of a 2-1/4 x 3-1/4 transparency. A six inch guide scope and hand held slow motion controls were used to obtain this exquisite example of celestial photography.

Photograph by Orien A. Ernest



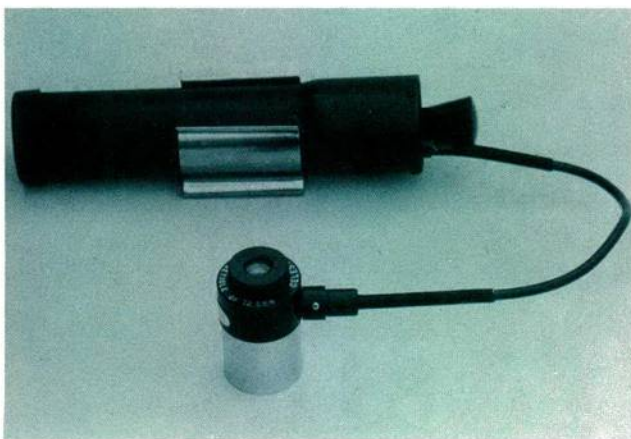


Photograph by Leo C. Henzl Jr.

This Dumbbell nebula portrait was shot through an eight inch Celestron telescope using an off-axis guiding eyepiece accessory. The 30 minute exposure on Kodak 103aF film reveals delicate texture in this planetary nebula that is not seen in photos with smaller apertures.

the control must permit corrections on the order of one second of arc.

Electronic drive correctors are available from many mail order sources. For their operation, they rely on the fact that the speed of a telescope drive depends on the frequency of the A.C. current it receives. Depressing the drive corrector's instantaneous "fast" or "slow" button yields an output frequency higher or lower respectively than normal 60 hertz house current. The main criterion here is sufficient "leverage" to "catch" an escaping guide star; an output of 50 Hz in "slow" and 70 Hz in "fast" is usually adequate. (Note: Don't be alarmed if your drive runs somewhat noisily with a drive



The illuminated reticle eyepiece accessory is really "night-time crosshairs". Otherwise invisible crosshairs are faintly lit by the battery pack which has a rheostat for setting the intensity to individual preferences and observing conditions.



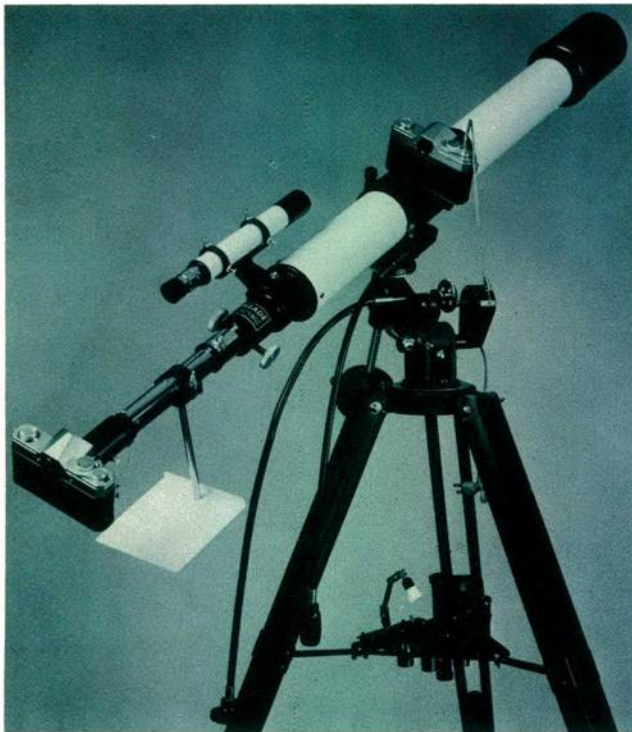
A drive corrector is a necessary accessory for many astrophotographic endeavors since it accommodates for normal electric drive inaccuracies and minor misalignments in the mount setup. The hand held control box makes for ease of operation during critical guiding sessions.

corrector. The waveform output of most units is square rather than sinusoidal, so slight buzzing is normal and harmless.)

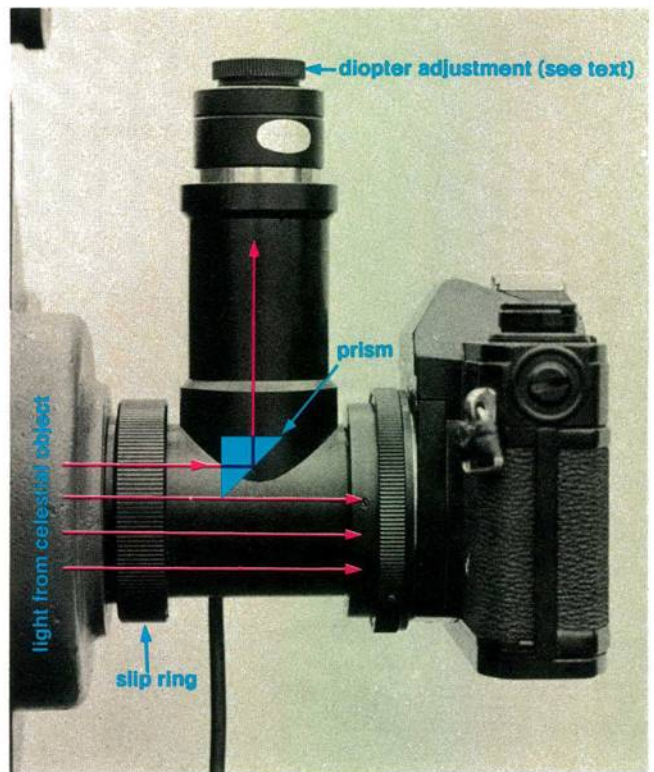
A variety of pros and cons are involved in the question of a separate guide scope versus an off-axis guider. The former is a complete, self-contained telescope — usually 1/3 to 1/2 the aperture of the main instrument — while the latter is a fairly simple device which intercepts a tiny portion of the telescope's beam — outside the actual photographic field — and diverts the light to a guiding ocular (see illustration). Common to either device is the need to attain relatively high power for accurate guiding. In general, the guiding magnification should be at least twice your shooting effective focal length in inches — for example, 160 power for an instrument of 80 inches EFL; higher ratios provide greater sensitivity. This isn't difficult to achieve with an off-axis guider, where guiding and shooting EFLs are identical. A typical guiding ocular of 1/2 inch focal length provides the necessary 2 to 1 ratio. With a separate guide scope of lesser EFL, however, a Barlow lens may be required.

Although costly and bulky, the separate guiding instrument is certainly the more flexible of the two systems. It is usually mounted to the main telescope with an adjustable bracket or twin rings (much like an overgrown finder). Since suitably bright guide stars are often located some distance from the photographic subject, an obvious advantage here is freedom to offset the guider's pointing position considerably from that of the main telescope. However, unless the coupling between the two instruments is totally rigid, the problem of *differential flexure* may result. Here,

flex and sag in the system produce apparent guiding errors, for which you duly correct — but to no avail. From the viewpoint of the camera's discrete optical system, the errors do not exist — and inaccurate guiding is the upshot. Even if you're certain of the system's mechanical integrity, there's still the possibility of *optical flexure* — slight



Your telescope's manual slow motion adjustments for declination should permit very smooth, small corrections — otherwise their use in astrophotography is limited. The Celestron declination adjustment is a fine-threaded system located on the fork mount. For ease in use at the eyepiece, the Meade 3.1 inch refractor has both declination and right ascension controls on flexible shafts.

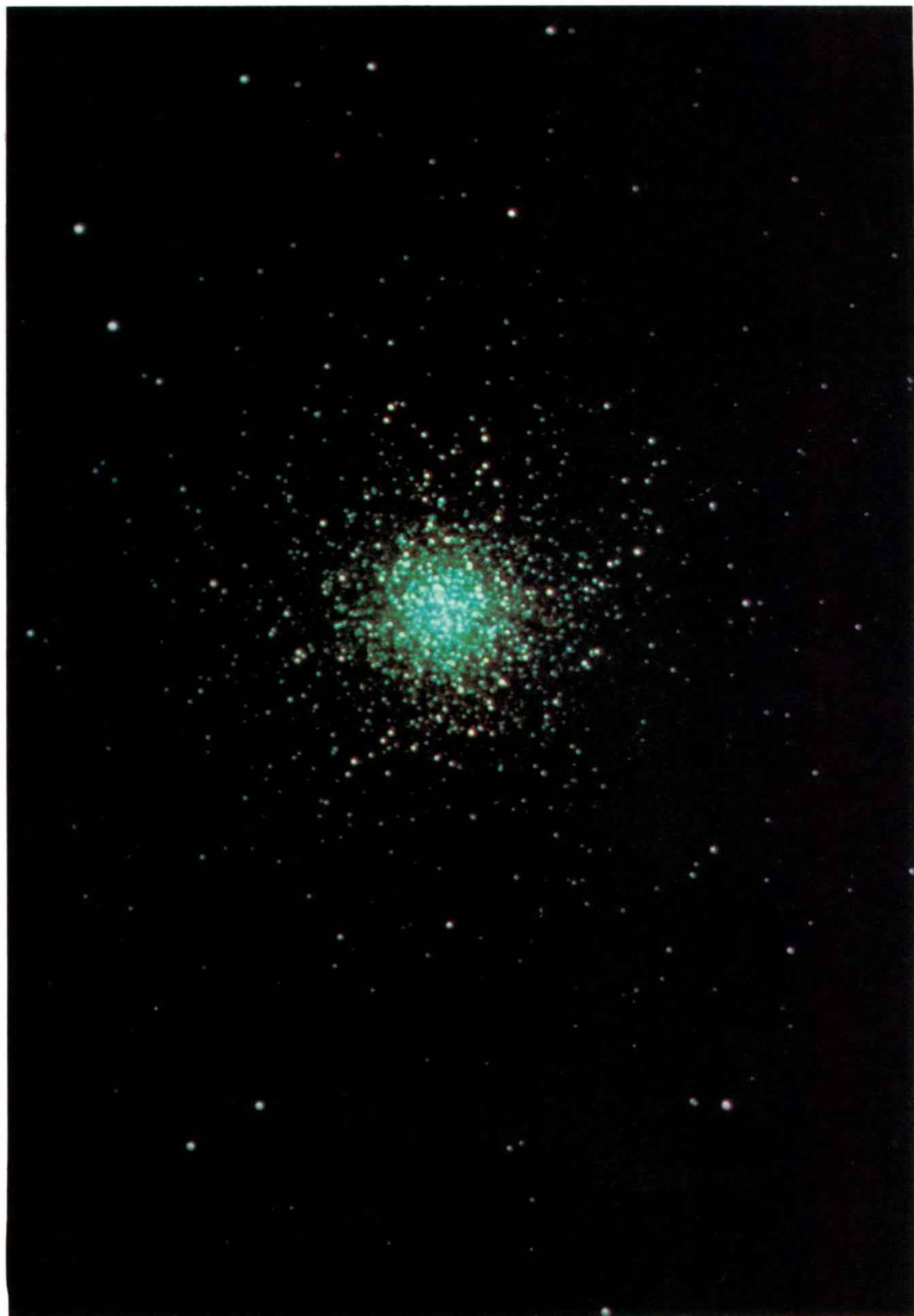


The use of an off-axis guiding accessory instead of a separate guiding telescope has both advantages and disadvantages. By utilizing the light from the main scope that is outside the 35mm camera's field of view, there is little chance for error — the same package of light that is passing on its way to the film is seen in the guider. The slip ring permits rotation of prism about field periphery until a suitable guide star is acquired. The only disadvantage in this setup is the occasional unavailability of a moderately bright guide star.

movement, perhaps, of the primary mirror in the shooting instrument, or sag in the secondary mirror support (both are conditions that the guiding instrument cannot disclose).

Problems of this sort are difficult to track down, because stress is often such that they manifest themselves in some parts of the sky, but not in others. If you've had inexplicable guiding anomalies with a separate guider, check for differential flexure by aiming both instruments — equipped with guiding oculars — at the same star. If a pointing discrepancy of more than a couple seconds of arc develops in the course of a typical exposure time, take a long, hard look at every nut, bolt and washer in the entire system.

The off-axis guider, on the other hand, is an inherently reliable device. Since it "sees" exactly the same field as the camera, it is able to detect any flexure that may occur during an exposure. It is also relatively inexpensive and compact in size. But off-axis guiding does have several drawbacks — the primary being that it doesn't provide the pointing freedom of the separate guider. You're limited in choice of guide star to those within the field coverage of your shooting instrument — typi-





Photograph by Leo C. Henzl Jr.

Sometimes called the Checkmark nebula, M-17 in Sagittarius is readily seen as a wispy glow in small telescopes. However, this 30 minute off-axis guided exposure on Kodak 103aF film

shows far more detail than the eight inch telescope employed for the photo could reveal visually. M-17 is about 6,000 light years distant.

cally within a degree or so of your subject. Then, because you're using the outer fringes of your instrument's field, the guiding image will vary from slightly aberrated to highly aberrated — depending on how far off-axis your guider operates, and on your telescope's edge-of-field performance. This, however, isn't quite as rugged as it might seem at first, because you do have the light grasp of your shooting instrument to call on, and can therefore often employ a fairly dim star for guiding. Only a few telescope suppliers currently offer off-axis guiding devices — all of these have been made strictly for their own telescopes — but many photographers have fabricated their own from inexpensive parts.

Whether your choice is for a separate or an off-axis guiding device, it will be equipped with an illuminated-reticle guiding ocular — usually a cross hairs type. Illumination is provided by a tiny "grain-of-wheat" light bulb or a light emitting

diode. Either way, the power supply should include a rheostat so that you're able to vary the illumination of the cross hairs for guide stars of differing brightness. It is also important that the reticle and guiding image fall in the same plane of focus for your eyesight. Otherwise, parallax will occur as you shift your head slightly while guiding — the result being, again, apparent but nonexistent guiding errors. To check for parallax, move your head slightly and watch for corresponding motion of a sharply focused guide star relative to your cross hairs; there should be none. Well-designated guiding oculars incorporate a diopter type adjustment, which will enable you to bring the two focal planes into coincidence. Without this adjustment, you may still be able to accomplish the same thing by shimming the reticle.

Of all the "equipment" in guided photography, you — the photographer — are by far the most important entity, since it's your proficiency with a drive corrector and declination control which determines — more than any other single factor — the ultimate resolution of your photos. A fine deep sky photo is truly a personal victory, but whether the winning is easy or difficult will depend greatly on the performance of the other links in your guiding system. 🐞

The Great Cluster in Hercules — a colossal ball of suns — is visible as a faint star to the unaided eye. Here, in a 35 minute exposure on cooled 35mm High Speed Ektachrome, a 14 inch Celestron telescope reveals many of the brighter of the cluster's estimated one million stars. Off-axis guiding was used for this photo.

Photograph by Leo C. Henzl Jr.



ASTRONOMY

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Preface by
CARL SAGAN

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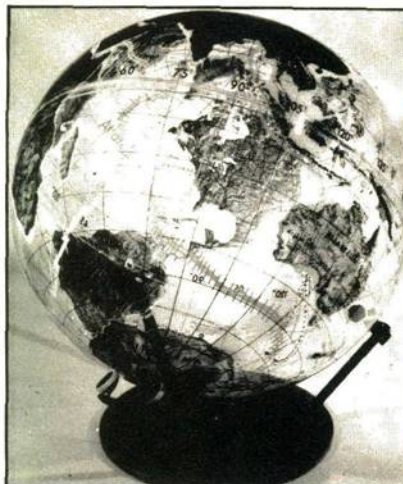
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Many readers continue to ask about the availability of ASTRONOMY back issues, but the majority blindly send us an order requesting issues we no longer have. For example, the October 1973 issue has been sold out for at least six months.

The following guide, which will be changed monthly, is designed to give you the most up-to-date information on the status of back issues. While they last, back issues are available for the cover price of \$1.50 each (price includes postage).

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

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ASTRO-NEWS

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Mars' Air Content Debated

The results of an experiment sent to Mars aboard a Soviet spacecraft in 1971 have sparked new speculations about the exact nature of the atmosphere of that most Earthlike planet.

Prior to the February 1974 announcement of the Soviet results, the Martian atmosphere — only 0.5 percent as dense as Earth's — was believed to consist almost entirely of carbon dioxide. Now, sparked by the Soviet report, new interpretations suggest significant amounts of the gas argon is present in the Martian atmosphere. If accurate, the finding would mean

Mars is much more like Earth than currently thought.

The 1971 Soviet exploration of Mars consisted of four spacecraft — two intended to orbit the planet and two landing vehicles. Only Mars 6, one of the landers, was successful in returning new information although it ceased to function just before reaching the Martian surface.

The critical data were obtained on the way down through the atmosphere, according to Joel E. Levine of NASA's Langley Research Center.

"During the parachute phase of Mars 6's descent, the ion pump of

the mass spectrometer (a gas analysis device) started its evacuation," Levine said. "To the surprise of the Russian scientists, the ion pump did not evacuate as it did in laboratory simulations in a pure carbon dioxide atmosphere. One obvious explanation was that the instrument malfunctioned."

A second possibility according to Levine was that large amounts of an unexpected inert gas (such as argon) could not be pumped out of the instrument. Since it is not easily ionized, argon is a very difficult gas to pump out of a mass spectrometer.

The initial reaction of the scientific community to the Soviet report was one of skepticism, believing that the instrument had malfunctioned. The instruments had indicated that 1/3 of the Martian atmosphere is argon, a totally unexpected result difficult to reconcile — at least at first.

Then in a November 1974 article in *Geophysical Research Letters*, Levine and Guenter R. Riegler of Bendix Aerospace Systems Division described a model of Martian argon production based on the "radiogenic decay of potassium-40 in the Martian interior". Their calculations indicate that "several tens of percent of argon are possible, and should be expected in the Martian atmosphere."

The Levine-Riegler calculations predict an argon abundance of about 28 percent. Interestingly, a 1947 calculation by Harrison Brown of the California Institute of Technology — based on the same reasoning — also predicted that argon may be a major constituent of the Martian atmosphere. "Somewhere along the line, Brown's prediction was forgotten," says Levine. "In more recent times, estimates of argon on Mars assumed that the terrestrial carbon dioxide/argon outgassing ratio was also valid for Mars. This method predicts very

Relay Satellites to Replace Ground Tracking Stations

In an age where space probes are constantly tracked for hundreds of millions of miles into the outer solar system, it may seem surprising that Earth-orbiting spacecraft are never in continuous contact with ground control. Earth satellites are only in touch with the ground about 15 percent of the time as their orbits carry them in and out of range of more than a dozen worldwide stations comprising NASA's Spaceflight Tracking and Data Network. (Interplanetary probes are monitored by five special deep space antennas.) Veteran spacewatchers might remember in particular when mission control yelled at America's first spacewalking astronaut, Edward White, to "Get back in!" (the space capsule) before he drifted out of radio range.

The upcoming Apollo/Soyuz space rendezvous will utilize a special relay satellite for increasing communication with the ground to 50 percent. The tiny relay station will be the forerunner of a more ambitious Tracking and Data Relay Satellite System (TDRSS) that NASA is planning for the 1980s. Two relay satellites in synchronous

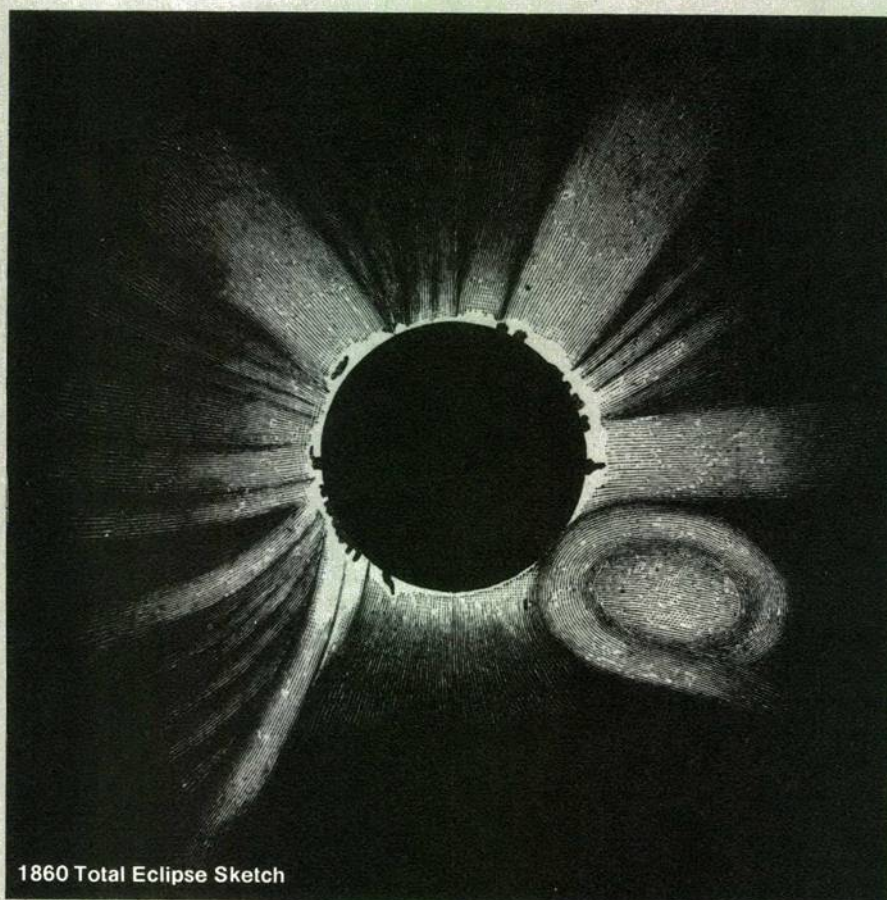
orbit — one over the Atlantic Ocean and one over the Pacific — will provide almost continuous coverage (85 percent) and simultaneous communication with up to 20 spacecraft. TDRSS would carry voice, telemetry, and commands between ground based mission control and the Space Shuttle, its scientific payload, and other satellites below 3,000 miles altitude. Such a communications system is a must if NASA is to conduct increasing activity in Earth orbit via the Space Shuttle orbital transport — which is scheduled for completion around 1980.

TDRSS will reduce costs by closing many ground tracking stations and their associated communications circuits. Although the first pair of satellites will be launched with expendable rockets, the Space Shuttle will further lower the TDRSS price tag by repairing or replacing these relay stations with follow-on spacecraft.

NASA expects to contract private industry for developing and operating the relay system under a 10 year agreement. ☛

Mars continued on page 63

Historic Solar Event Confirmed



1860 Total Eclipse Sketch

Before the advent of photography, astronomers recorded the appearance of astronomical objects with drawings and sketches. For the moon and planets this method was quite satisfactory and, in fact, is occasionally used today to add detail to photographs of these bodies.

A century ago, astronomers would sit at the eyepiece for many minutes or even hours to ensure no detail was missed. However, problems arose during attempts to get a pictorial record during a total solar eclipse. Because of the rarity and short duration (less than seven minutes) of these events, an astronomer had to work furiously to sketch the structure of the solar corona in hopes that a permanent record might eventually help determine the nature of the corona.

During solar eclipses the corona can be seen streaming out from the sun, forming a ghostly halo in the sky. On July 18, 1860, an eclipse occurred which was sketched by many astronomers who had assembled along the zone of totality in Spain. Notable amongst the drawings produced was one by the Italian astronomer Guglielmo Tempel. He showed a whorl-like pattern in the corona. Some other astronomers also sketched looplike structures with less clarity.

No such structures had ever been noted before, nor were they ever seen again during an eclipse. As a result, those old observations were treated with skepticism and indeed were used as proof to illustrate how little reliance could be placed on drawings made by observers whether they were trained astronomers or not. The famous astronomer George Ellery Hale said in 1900, "The experience of previous eclipses has shown that drawings of the corona for the most part serve no useful purpose unless it be to illustrate the personal peculiarities of the draftsman."

Time was to prove Hale wrong in this particular matter — when the Skylab astronauts photographed no less than 24 events of the type sketched back in 1860. These events are called *transients* — a designation referring to their temporary nature. They are structures — usually shaped like giant bubbles — which move very rapidly up through the solar atmosphere. The Skylab observations show that the transients occur about once every 100 hours on the average; at that rate it can be calculated that we would expect to see one only once every 100 years during eclipses.



1974 Skylab Coronagraph Photo

Events

continued on page 64

low argon concentrations that vary from a few hundredths of a percent to several percent of argon at most. The predicted low argon concentrations could result from an underestimation of the total amount of carbon dioxide outgassed on Mars."

Unfortunately, argon cannot be measured directly by ground based telescopes since its resonance lines are in the inaccessible extreme ultraviolet. The UV spectrometer aboard Mariner 9 did not extend far enough into the extreme ultraviolet to detect argon's lines. However, argon's presence may be indirectly deduced from Earth by its so-called pressure broadening effect on carbon dioxide.

Lewis Kaplan of the University of Chicago has examined some recent high resolution Mars carbon dioxide spectra obtained with a newly improved Michelson interferometric spectrometer and the Palomar 200 inch telescope. Preliminary analysis of the spectra by Kaplan does indeed suggest "several tens of percents" of argon in the Martian atmosphere.

In 1971, Donald Hunten of Kitt Peak National Observatory reported that the total pressure measurement of the Martian atmosphere deduced by the Mariner radio occultation method is consistent with either a pure carbon dioxide atmosphere or with various mixtures such as 80 percent carbon dioxide, and either 20 percent argon or 20 percent nitrogen.

Levine believes the presence of several tens of percent of argon on Mars has very important implications for the evolution of the Martian atmosphere. "The atmosphere of Mars, like Earth's atmosphere, is believed to be secondary — having outgassed from the planetary interior where the gases were trapped during the process of planetary accretion."

According to Tobias Owen of the State University of New York, the amount of argon is an indicator of the total outgassing on Mars. Levine estimates that about 50 million times as much water than now appears in the Martian atmosphere was once outgassed on Mars. There should also be about 500 times more carbon dioxide than we now see, Levine says. The Levine estimate provides the carbon dioxide that Carl Sagan of Cornell University has suggested is trapped in the summer north polar cap remnant, and that Fraser P. Fanale and William A. Cannon of the Jet Propulsion Laboratory have suggested is physically adsorbed to the Martian surface regolith.

However, the large quantity of water predicted by Levine (the equivalent

of three-mile-deep oceans over the entire Martian surface) is very difficult to reconcile with current estimates of surface and subsurface permafrost and water physically adsorbed and chemically bound to the surface regolith.

Yet the presence of large amounts of liquid water on Mars sometime in the past may explain the intriguing surface features resembling meandering dried river beds complete with tributary systems photographed by Mariner 9. The prediction that large amounts of water outgassed on Mars coupled with the Mariner 9 surface photographs of dried river beds suggest that Mars may have somehow lost the equivalent of Earth's oceans. Another possibility is that large amounts of as

yet undiscovered water exist on Mars. The biological implications of such large amounts of water on Mars past or present are very important.

The conclusive answer to the question of argon on Mars may have to wait until the summer of 1976 when two Viking craft land on Mars. The Viking landers will measure argon directly, if it is present. A negative argon result would suggest that either the Martian interior is deficient in potassium-40 or that Mars has not undergone internal differentiation or has not experienced outgassing to the same extent as has Earth. In either case, a precise argon measurement will tell us something important about the evolutionary history of Mars. ☛

Cosmic Rays May Come From Galactic Center

Every second, high energy bullets of individual protons and heavier atomic nuclei crash into Earth's atmosphere as cosmic rays. As some scientists study how this continuous atomic shower might influence such earthly events as biological mutations and thunderstorms (see *ASTRONOMY*, May 1974), astronomers are still wondering where cosmic rays come from.

Some relatively low energy cosmic rays are generated by the sun, but the high energy particles could be tagged to a number of violent events in the universe, ranging from supernovas to quasars — extremely distant and unusually powerful sources of light and radio.

An important underlying question asks whether cosmic rays originate within the Milky Way galaxy or reach us from the universe as a whole. If these particles belong to our galaxy, they should radiate from a particular direction — most likely the galactic center where much of the Milky Way's star population is concentrated. If, instead, the entire universe generates cosmic rays, they should flood Earth equally from all directions — because we assume that the universe is evenly distributed around us.

A study by physicists A. M. Hillas and M. Ouldrige of England's Leeds University now suggests that cosmic rays are not smoothly spread out across the sky. The researchers base their conclusions on the combined results of four major cosmic ray observations using instruments in Australia, the United States and England. The detectors record showers of particles from atoms in Earth's atmosphere that are broken apart by collisions with incoming cosmic rays.

Both the British team and an independent Soviet study of much of the same data find *three* cosmic ray concentrations. Surprisingly, none appears to radiate from the galactic center, and only one source lies within the plane of the galaxy. Another region of intensity exists almost directly below the galactic center, but far out of the galaxy's disk. A third source radiates from above the Milky Way.

So far, this puzzling cosmic ray distribution has not settled the problem of galactic versus extragalactic origin. Although cosmic rays appear to favor some directions over others, the two locations of intensity outside the galactic plane could infer that they come from beyond the Milky Way. In particular, one source overlaps the Virgo supercluster of galaxies that our Milky Way belongs to. The only source within the galactic plane lies in the direction of a pulsar in the constellation Vela, but experts caution that it might only be a coincidence.

Hillas and Ouldrige suggest that all three locations may really represent cosmic rays that have been deflected by the galaxy's magnetic field. They propose that cosmic rays streaming out from the Milky Way's center eventually flow back into the galaxy along magnetic lines. This implies that the galaxy's field extends thousands of light-years beyond the galactic disk.

However, the actual shape and extent of the Milky Way's magnetic field is still very vague. Astronomers suspect that the field is much more complex than it now appears. But until a clear model can be made, the true nature of the cosmic ray peaks may remain unknown. ☛

Apollo/Soyuz to Study Cosmic Rays

Future astronauts on long interplanetary missions will be strolling along the back wall of a nuclear shooting gallery. The bullets in this case are cosmic rays — extremely high speed (almost the velocity of light), high energy atomic particles that easily penetrate the hull of a spaceship or the human body. In a real shooting gallery, the chances of getting hurt increase the longer someone remains a target. Scientists want to find out if the same risk holds true for space travel.

Cosmic rays ionize, or capture electrons from materials the particles pass through. For living things, this means cellular damage and disruption of bodily processes. In particular, HZE particles — relatively heavy carbon, nitrogen, oxygen and iron nuclei — can release enough energy to kill a cell. The body replaces most of these lost cells except for the neurons, comprising the retina, spinal cord and brain. Once a nerve cell goes, it is destroyed for good.

How would this constant trickle of HZE particles, radiating from the sun and unknown galactic or extragalactic sources, affect an astronaut's overall health? Experts are undecided. They are only familiar with large volume particle dosages in victims of industrial nuclear accidents or survivors of the Hiroshima and Nagasaki atomic bomb blasts.

"Some researchers," says J. Vernon Bailey of the Health Services Division at NASA's Johnson Space Center, "suggest that on a 1,000 day mission to Mars, perhaps 10 percent of the brain cells would be killed by HZE particles. But, since we think that even the most intelligent human probably doesn't use more than 10 percent of the total cells in his brain, are these HZE particles really a hazard?"

"We don't think that these cosmic ray effects mean that there's going to be serious damage on interplanetary flights," concludes T. F. Budinger of the University of California's Lawrence Radiation Laboratory. "We just think that this phenomenon should be carefully studied."

Experiments to be flown on next July's space rendezvous between an Apollo and Soviet Soyuz spacecraft promise new insights into the cosmic ray question. One experiment called "Biostack" will identify what biological specimens have been hit by HZE particles. Researchers will look for cellular damage, molecular damage, and mutations in the returned collection of one-celled organisms, brine shrimp, insect eggs and similar creatures. The

behavior of this sample will be compared to an identical microscopic zoo left behind on Earth, and a third set of specimens that flew into space under relatively strong shielding against cosmic rays.

Biostack consists of two 4 x 5 inch packages containing layers of biological specimens sandwiched between photographic film and plastic nuclear particle detectors. The film and detectors will chemically record the direction and type of HZE particle piercing Biostack, and specify what specimens were hit. Biostack will be placed in an area of the Apollo Command Module that has little shielding from cosmic rays.

United States and Soviet experimenters plan to jointly study how HZE particles also affect a species of bacteria known as *zone forming fungi* because of its unique radial growth pattern. Co-experimenter Gerald Taylor of the Johnson Space Center believes that a disruption in this zone forming growth could indicate that a cosmic ray collision caused the bacteria to "forget" how it was radially developing.

During the mission, astronauts will actually try to "see" cosmic rays. Crews on the Apollo lunar flights first noticed flashes within their eyes which scientists believe were triggered by particles striking the retina. Now for the first time astronaut observations will be compared to what instruments on board actually measure. The crew will increase their sensitivity to particle flashes by

wearing light-tight masks for dark adaption. Meanwhile, a crystal material mounted on the mask will record tracks of incoming particles as another detector identifies types of particles by measuring their mass, trajectory and energy.

Apollo's orbit will carry it through regions where the Van Allen radiation belts (where Earth's magnetic field traps particles streaming from the sun) dip closer to Earth than normal. So at certain latitudes, especially near the location of the north and south magnetic poles (the regions particles are magnetically directed toward), astronauts should experience perhaps 10 minute light shows produced by protons and HZE particles.

Budinger, principal investigator on this experiment, says that protons might appear at a conservative rate of 10 to 20 per minute, and might possibly resemble snow flurries. The heavier, more energetic and destructive HZE particles should appear brighter, and at a slower rate of one or two per minute.

Although Budinger confesses that the particle influx problem is too complex to be solved on the few orbits scheduled for the experiment, it will still give scientists a better idea of the frequency of these impacts. The batch of results from this last Apollo flight will hopefully keep researchers busy until much longer duration experiments can be performed on the Space Shuttle flights of the 1980s. ☛

Events continued from page 61

In a recent article in **Astronomy and Astrophysics**, Jack A. Eddy of the High Altitude Observatory in Boulder, Co. reports on the sighting of the coronal transient of 1860. The Skylab data on similar transients show that they move upward in the solar corona at between 100 and 300 miles per second. At that speed, observers at various points along the path of the eclipse might record differences in the coronal structure.

The transients are very hard to see because they occur in the outer part of the corona where the light intensity is low and usually swamped with glare from the inner corona. The coronagraph on board Skylab used a radial density filter which transmits less light in from the bright part of the corona than from the dimmer outer parts of the sun's atmosphere. This revealed the transients very clearly.

An interesting sidelight to this story concerns a drawing of the 1860 eclipse made by Father Pietro Secchi, a better known astronomer than Tempel. Secchi, apparently more interested in the lower corona, did not show the transient at all even though he was only a few miles from Tempel's location. It is probably true that most scientists looking at both sketches believed the better known observer and discounted the work of Tempel. However, recent re-examination of other drawings of this eclipse shows that they tend to confirm Tempel's rendering since most of them have hints of the feature he drew clearly.

Time has finally proven that a scientist's reputation — at least in this case — is not a basis for judgement of his worth as an observer. As Eddy concludes in his paper, there is probably a lesson to be learned here. ☛

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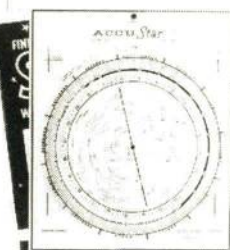
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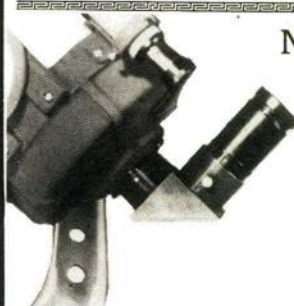
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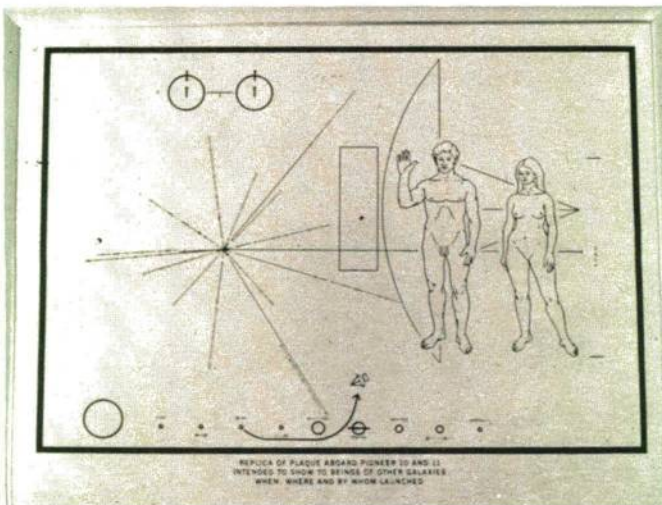
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STAR DOME

JULY

No doubt the night sky draws more interest and attention during the summer than any other time of the year. Vacations into the deep country or to the ocean offer a special opportunity to see the stars in their full splendor. In addition, warm nights invite long lazy hours of stargazing.

It's little surprise that the earliest civilizations sought to make some sense and order out of the myriad lights in the sky. Stars were mentally arranged into a richly imaginative collection of people and animals now known as the constellations. Elaborate tales of godlike warriors, magical beasts and eternal love explained the figures' presence overhead as they paraded nightly above the horizon.

To city dwellers, the first glance into a country sky can be both overwhelming and frustrating. Star patterns that were dominant even in the glow of urban lights melt into a star-sprinkled tapestry of over 2,000 stars. Observers lost in this starry camouflage should first turn to the Big Dipper, high above the northern horizon this time of year. People often mistake the Big Dipper for a constellation, when it is in reality a star pattern. However, the Dipper does comprise the tail and hindquarters of Ursa Major, the great bear — a well-known creature in many ancient sky legends.

As a star pattern, the Big Dipper is an invaluable guidepost for both beginning and veteran stargazers. A line extended from Merak (the bottom star in the end of the Dipper's cup) through Dubhe (in the Dipper's rim) leads directly to Polaris, the north star — pivot point for the imaginary axis around which the star dome seems to turn. Continued in the opposite direction, the line leads to the blue-white star Regulus in the constellation Leo the lion, now low on the western horizon. And an arc, followed from the Big Dipper's curving handle, points to yellowish Arcturus and to Spica beyond.

The Milky Way's hazy band of light now arcing across the eastern sky intersects the Summer Triangle, a large formation of three very bright

stars. At the triangle's southernmost point lies +0.9 magnitude Altair. Imagine two sides of the triangle stretching up to bright Deneb on the left, and Vega on the right.

After staking out these prominent stars, they can be helpful in finding special summer sky attractions. For example, halfway between Vega and Arcturus lies a shimmering crescent of seven closely spaced stars — Corona Borealis, the northern crown.

In mythology, this unusually beautiful constellation symbolizes a god's love for a mortal woman. The woman was Princess Ariadne, daughter of King Minos of Crete. Minos periodically sacrificed several Athenian people to the dreaded Minotaur, a half-man, half-bull creature who dined exclusively on human flesh. Ariadne fell in love with one of the intended victims, the Greek hero Theseus. Ariadne promised to help Theseus carry out his real mission — to kill the Minotaur — if in return the hero would marry her.

Theseus' biggest worry was not so much about killing the beast, but rather finding his way out of the Minotaur's cage, the Labyrinth (an intricate maze of pathways that forever trapped victims). So Ariadne gave Theseus a ball of string to unravel as he searched the Labyrinth for the Minotaur. Even a Minotaur needs sleep, and unfortunately it chose to take a catnap just before Theseus arrived. Our hero beat the Minotaur to death with his bare hands, and then smoothly exited via the trail of twine.

But apparently it was easier for Theseus to duel with the terrible Minotaur than to face the prospect of marriage. He grabbed the next boat out of Crete and left Ariadne crying on the shore. The god Dionysius came upon the jilted princess and immediately fell in love with her. To prove that he really was a god and not one of those marriage-shy mortal men, Dionysius tossed a golden crown skyward where seven bright stars danced around it. This shimmering crown became Ariadne's wedding gift, and was lovingly worn by her until death. The



Photograph by Leo C. Henzl Jr.

Thirty-five thousand light-years distant, several hundred thousand stars huddle in a gravitationally bound cluster 220 light-

years across. This photo of M-3, taken with a 14 inch telescope, shows more stars than can be detected visually.

crown then returned to the heavens as an eternal symbol of Dionysius' affection. Meanwhile, Theseus was punished for being such a heel by never being granted immortality among the stars.

As with all constellations, each star within Corona Borealis is streaking through space in its own particular direction and speed. In another 100,000 years, the crown's smooth crescent will have broken up into a more random scattering of stars. In particular, Gemma — the brightest star in the crown and one somewhat like our sun in size and temperature — belongs to a bypassing group of stars only tens of light-years away. Millions of years from now, Gemma and other group stars including Sirius and five stars in Ursa Major will converge into a more distinguishable cluster as they recede from us.

Some old maps picture Corona Borealis as the upraised arm of Bootes, the constellation to the right of the crown. The bright stars form a kite shaped pattern in this region, highlighted by brilliant yellow Arcturus in the base of the kite.

Bootes is often depicted as a hunter or herdsman driving (or chasing) nearby Ursa Major (the big bear) around the north celestial pole. To the Egyptians, Bootes was the mother goddess Apet or Taueret. She kept eternal watch on the circumpolar stars which were never allowed to set because they were supposedly evil. Bootes' relatively close proximity to the northern sky pole has also cast him in the role of Atlas — condemned to forever hold up the sky.

Close-Up

on the Bootes/Corona Borealis Region

The kite shape of the main stars of Bootes and the Corona Borealis crown give this month's region a distinctive visual appearance that contrasts with the faint areas to the east. The visual magnet of the region is Arcturus (arc-TOUR-us) which, at zero magnitude, far outshines anything for several constellations in any direction. The region is also heavily populated with moderately bright stars as well. Let's make a list of them to see if any relationships emerge.

Name	Magnitude	Distance (light-years)	Proper Motion
Arcturus	-0.1	36	2.28"
Gemma	+2.2	76	0.15"
Epsilon (ε) Bootis	+2.4	103	0.05"
Eta (η) Bootis	+2.7	32	0.37"
Gamma (γ) Bootis	+3.1	118	0.19"
Delta (δ) Bootis	+3.5	140	0.15"
Beta (β) Bootis	+3.5	140	0.06"
Beta (β) Coronae Borealis	+3.7	100	0.19"

We listed *proper motion* — the star's apparent movement across the sky per year — because Arcturus has one of the largest such motions of any

This Star Dome rendering approximates the sky as it appears at about 11 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.

EAST

NORTH



Map by Adolf Schaller

SOUTH



Map Centered on 40° North Latitude

star. Unlike most stars which follow the crowd (our sun included) in their multimillion year circuit of the galaxy, Arcturus is in a looping path that is cutting through the dense star clouds of the Milky Way. As a result of its relatively rapid motion, Arcturus has moved 2-1/2 times the moon's apparent diameter in the last 20 centuries.

Arcturus itself is a giant star of spectral class K, having some 80 times our sun's intrinsic luminosity. It is also among the closer stars at a distance of 36 light-years. Although we did not list the spectral characteristics of each star, an examination of such a list shows no real correlation among this group — nor do the distances reveal any surprises. These stars are all more luminous than the sun, but not supergiants like Rigel, Betelgeuse or Deneb.

The only thing slightly unusual is that five of the eight are doubles — one of them an outstanding telescopic sight (see below). Gemma, Eta (η) and Beta (β) Bootis are all *spectroscopic doubles*; that is, their multiple natures were detected by telltale shifts in their spectral lines. Delta (δ) and Epsilon (ϵ) Bootis are both *telescopic doubles*.

In a random group of stars, how many on the average are multiple? It depends on the group. Intrinsically bright stars seem to have companions more frequently than fainter stars. Among the 44 star systems within 17 light-years of the sun, there are two triple systems, 11 doubles and 31 single stars. It's probably safe to say that 1/3 of the stars in the sky are double or multiple suns. Brighter stars, as we mentioned, seem to have a higher ratio — something like one to one.

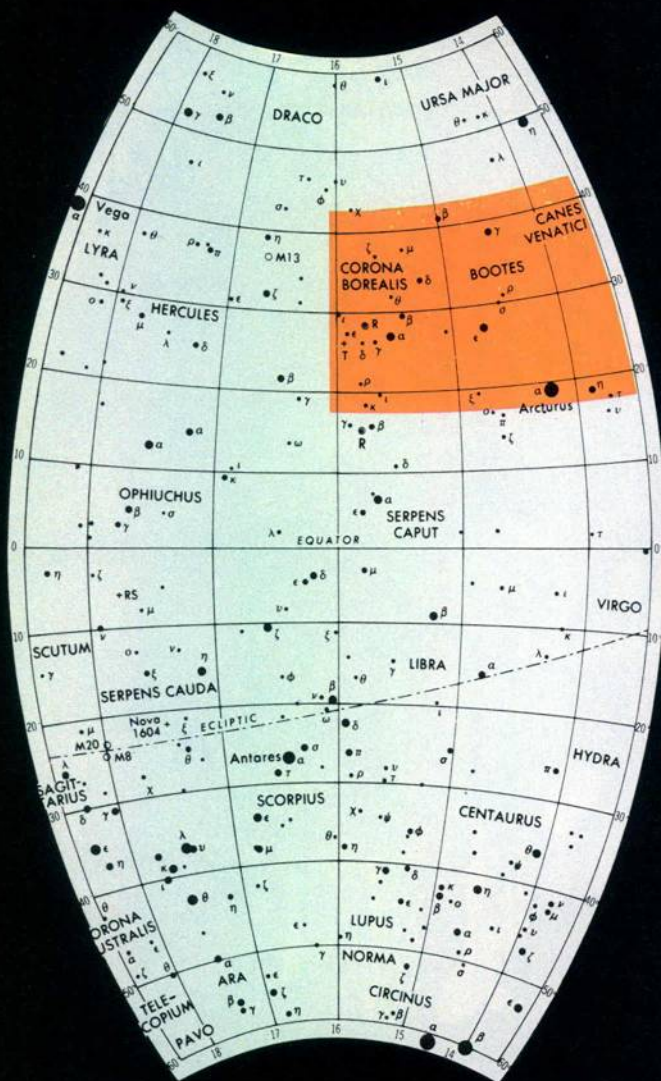
The Bootes/Corona Borealis region seems somewhat rich in doubles compared to other sky areas, as we shall see in the following section. It's probably just a random concentration.

Eyepiece Impressions

Last month we explored a remote section of the Coma-Virgo region known as the "Realm of the Galaxies". This month's area might well be called the "Realm of the Doubles", for large numbers of double and multiple stars occupy this part of the heavens which is otherwise poor in deep sky objects. With the single exception of a bright globular cluster, the showpieces here are twin and triplet suns — some are easy binocular subjects, and others are difficult pairs at the limits of the best amateur instruments. These stellar jewels — no two of which are alike — make leisurely stargazing on warm summer evenings a memorable experience.

M-3

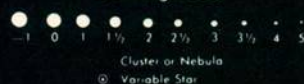
"Pre-eminent in its class..." "Very remarkable."
"A brilliant and beautiful globular congregation..."



Stars in each constellation are indicated in order of brightness with the Greek Alphabet

α Alpha	η Eta	ν Nu	τ Tau
β Beta	θ Theta	ξ Xi	υ Upsilon
γ Gamma	ι Iota	$\omicron$ Omicron	ϕ Phi
δ Delta	κ Kappa	π Pi	χ Chi
ϵ Epsilon	λ Lambda	ρ Rho	ψ Psi
ζ Zeta	μ Mu	σ Sigma	ω Omega

Star Magnitudes



Map from **Guideposts to the Stars**, reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

TABLE OF OBJECTS — BOOTES/CORONA BOREALIS REGION

Object	Type	Magnitude	Size/Separation	R.A. (1950)	Dec.
* M-3 (Canes Venatici)	globular cluster	6.4	10'	13 ^h 40 ^m	+28°38'
NGC-5466 (Bootes)	globular cluster	8.5	5'	14 ^h 03 ^m	+28°46'
* Arcturus (Bootes)	orange star	0.2		14 ^h 13 ^m	+19°27'
* ϵ Bootis	double star	2.7, 5.1	3"	14 ^h 43 ^m	+27°17'
ξ Bootis	double star	4.8, 6.9	7"	14 ^h 49 ^m	+19°18'
ζ Bootis	binocular double	3.5, 7.5	105"	15 ^h 13 ^m	+33°30'
* μ Bootis	triple star	4.5, 7.2, 7.8	109", 2"	15 ^h 23 ^m	+37°33'
η Coronae Borealis	double star	5.7, 6.0	0.8"	15 ^h 21 ^m	+30°28'
* ζ Coronae Borealis	double star	5.1, 6.0	6"	15 ^h 38 ^m	+36°48'
* R Coronae Borealis	variable star	5.8-14.8		15 ^h 46 ^m	+28°19'
* T Coronae Borealis	recurrent nova	2.0-10.8		15 ^h 57 ^m	+26°04'
σ Coronae Borealis	double star	5.7, 6.7	6"	16 ^h 13 ^m	+33°59'

*Detailed description in Eyepiece Impressions

"Blazing splendidly." Such are the superlatives used by many of the great observers of the past in their attempts to describe M-3, leader of the flock of bright globular clusters in late spring and early summer skies.

Point your telescope's finder near the midpoint of a line joining Arcturus and Cor Caroli, and there you will see an apparent "double star" — one component of which has a fuzzy appearance. This is M-3, a distant beehive of stars located some 40,000 light-years out in the halo of our Milky Way galaxy. The combined light of the two objects has been seen with the unaided eye under good conditions.

M-3 looks like a circular blur of light with a bright center in a three inch refractor at 45 power, but a four inch reflector at 70 power clearly reveals hosts of individual stars around the edge of the cluster. Eight inch and larger telescopes achieve resolution right into the nucleus, while the view in apertures over 12 inches is simply indescribable.

While dark nights of high atmospheric transparency are always to be sought for observing deep sky objects, really impressive views of globulars require good image steadiness as well. Such conditions allow the thousands of individual pinpoints of light from the cluster stars to reach the retina of the eye undisturbed. With a given telescope — depending on the seeing quality — M-3 can appear either as a featureless glow of light or like a celestial bundle of fiber optics!

Important, too, is careful focusing. The nearby fifth magnitude star mentioned above will be ideal for the purpose.

An unusual feature of M-3 is the large number of cluster type variable stars found within its confines — most having periods only half a day long. Such stars provide valuable physical data and have resulted in the allotment of considerable large telescope time to the study of this 200 light-year wide ball of stars. We cannot but help wonder about the view that must greet the astronomer upon setting some huge instrument on the cluster for a night's work.

Arcturus

Shining at magnitude +0.2, Alpha (α) Bootis — Arcturus — ranks as the third brightest star visible from northern latitudes, coming after Sirius and Vega, and just ahead of Capella. Its distinctive orange hue, as Webb points out, makes this star "a noble object at all times...."

In general, the bright stars are neglected by amateurs as far as telescopic work is concerned. Few vary appreciably in brightness or have interesting companions, and yet they possess a charm all their own for those who enjoy observing star colors (an indication of stellar temperature).

Perhaps the most exciting way of observing the hues of bright stars is to look at their spurious *diffraction disks*. These are a result of the wave

nature of light and are visible at high magnification in the telescope. And it is here that the small telescope user has a definite advantage over a large one, for the apparent size of the disks *increases* as the aperture used *decreases*. The disks and attendant rings in a 2.4 inch (60mm) refractor at 100 power or more are simply magnificent to behold, but in a six inch at the same power they are virtually invisible. Whatever size telescope you have, for a real treat try masking it down to one inch aperture using a cardboard stop (on-axis for refractors, off-axis for reflectors and compound systems). Our sketch of Arcturus shows the result!

An interesting project might be the compilation of a list of bright star colors based on diffraction disk studies. The use of well corrected eyepieces (and Barlow if used) and observing the stars on or near the meridian are two important factors in such a program. Although subjective in nature, such a tabulation would be internally consistent for any given observer using the same instrument for all the observations. Upon completion, the list of colors could then be compared to the actual spectral types listed in catalogs for the stars.

Epsilon (ϵ) Bootis

The real showpiece among the double stars of this month's region is the third magnitude star Epsilon, some 10 degrees northeast of Arcturus, in the kite shaped figure of Bootes. A stunning combination of yellow and blue-green suns, this pair is considered by many observers to be among the top half dozen "best" doubles in the sky due to its extreme beauty.

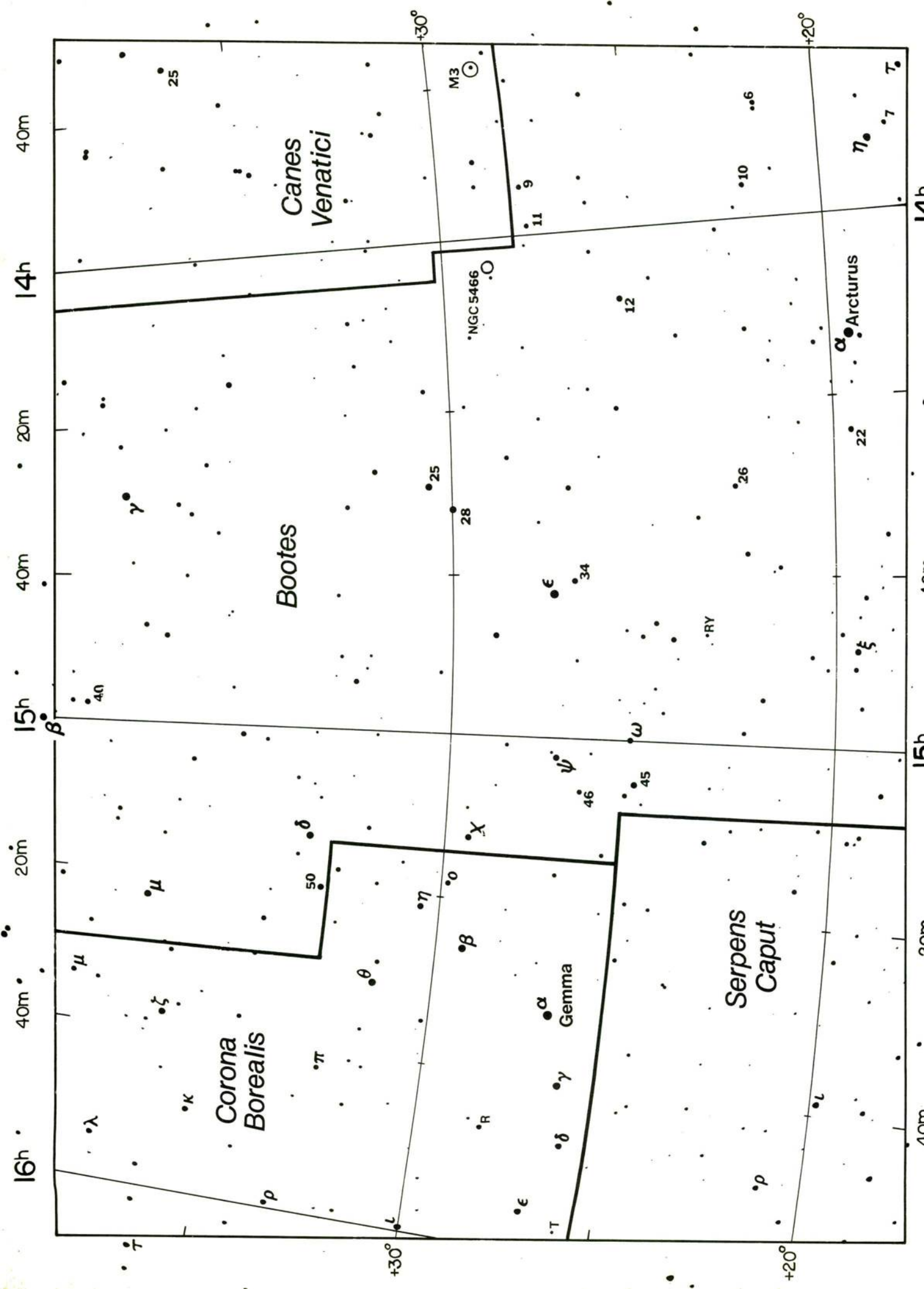
Having a separation between components of just three seconds, Epsilon is considered a test star for small instruments because the fainter star, at magnitude 5.0, is somewhat overpowered. However, a good three inch refractor will readily split the pair at 75 to 100 power in good seeing. Less than average seeing, on the other hand, quickly makes this object difficult to resolve in even a good six or eight inch reflector.

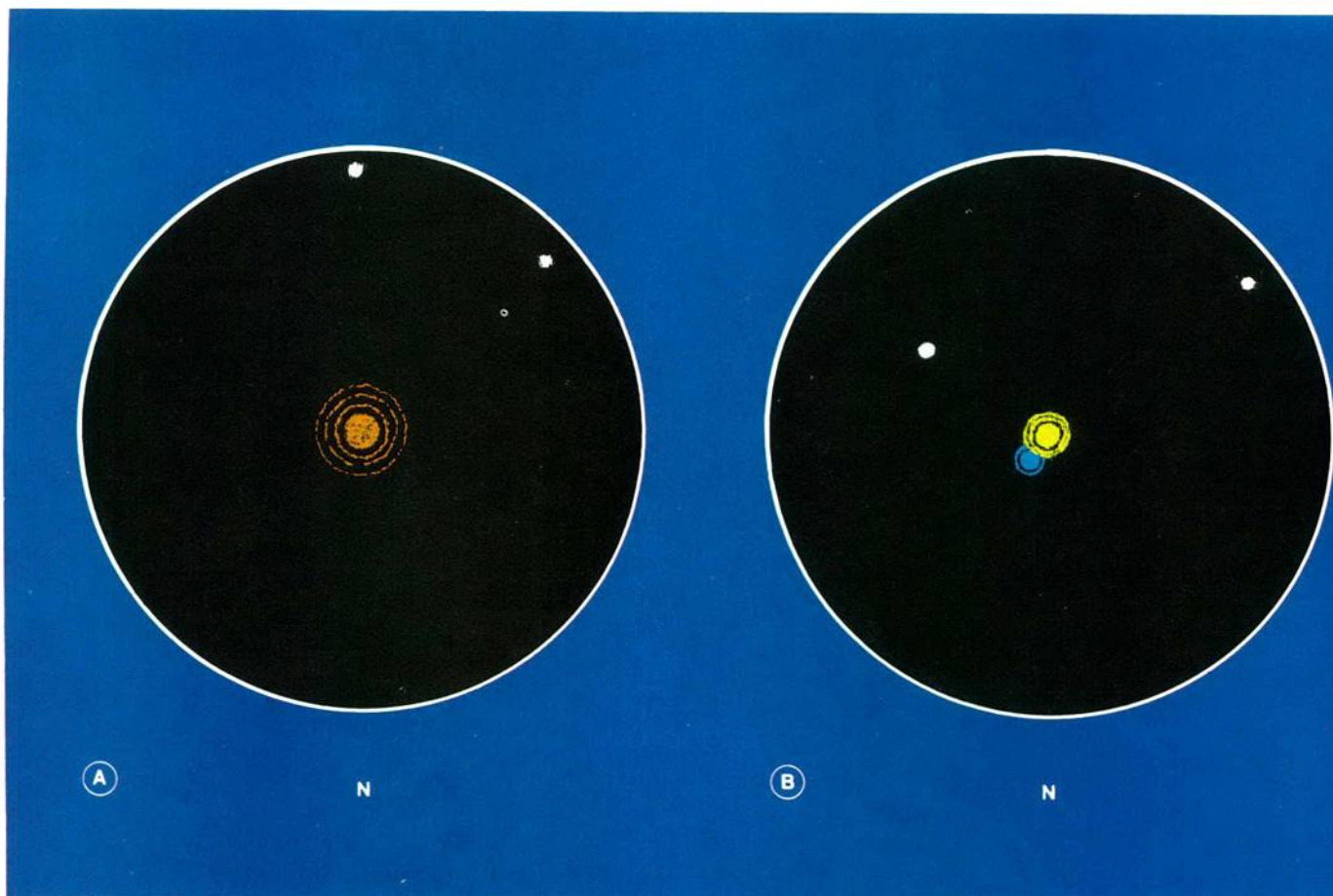
Other color combinations given for this object include orange and green — but most observers see the primary as golden yellow and its companion as either blue or green. Here again, the diffraction disks seen in small telescopes are ideal for viewing the contrasting hues. Although large amateur instruments more easily resolve the pair, their increased light grasp overwhelms the eye, reducing its sensitivity to subtle colors.

Surely those who lament the fact that they have only a small telescope would do well to consider that their humble instrument is capable of providing views of colored gems like Epsilon unmatched in any telescope — no matter how large it may be.

Mu (μ) Bootis

Continuing northeastward — along a line from





(A)
At a relatively nearby distance of 37 light-years from Earth, yellow-orange Arcturus blazes in this 10 second of arc field of view. A three inch Unitron refractor stopped down to a one inch aperture was employed to produce the bright diffraction ring framing Arcturus. The view is through a 180 power eyepiece.

(B)
An especially clear night and a 120 power eyepiece on a 2.4 inch Sears refractor separates the yellow and blue-green star pair Epsilon Bootes, or Mirak. One of the most dazzling binaries in the northern sky, sluggish Mirak has not exhibited any definite orbital motion since its discovery 146 years ago. The field of view is 15 seconds of arc.

(C)
The beautiful triple star system Mu Bootes nicely fits into this 1/2 degree field of view. A 70 power eyepiece on a four inch Edmund reflector resolves the two sunlike reddish stars that are only separated by two seconds of arc — while 180 seconds away sits the 4.3 magnitude blue-white member of the trinary.

(D)
The pastel blue and green star pair Zeta Corona Borealis makes a noteworthy gem among the stars comprising the northern crown. The binary stands out prominently in this view through a 160 power eyepiece on a 3.5 inch Questar telescope.

Arcturus through Epsilon — we come to a neat triple star system. This is the fourth magnitude star Mu which forms an obvious triangle with Beta (β) and Delta (δ) Bootis. A four inch telescope at 70

power reveals a bright bluish white star which has — at a distance of 108 seconds from it — a pair of seventh magnitude reddish suns, separated by just two seconds.

A 2.4 inch refractor usually shows the close pair as only an elongated egg, apparently circling the primary in some vast orbit. Although requiring steady nights to be well seen at all, Mu is one of the finest triples in the summer sky

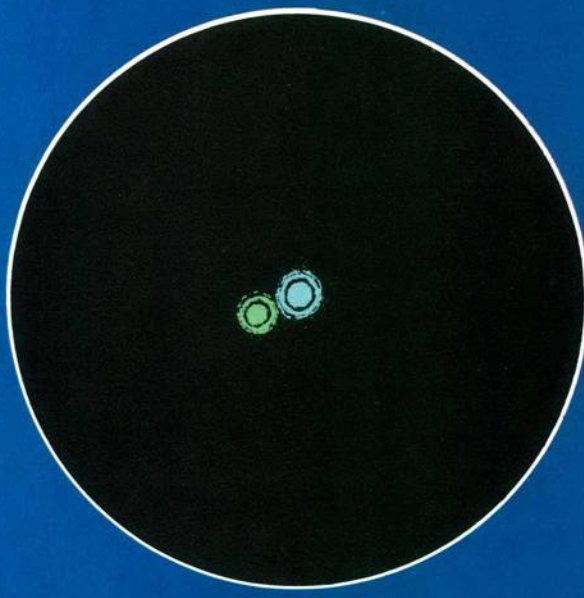
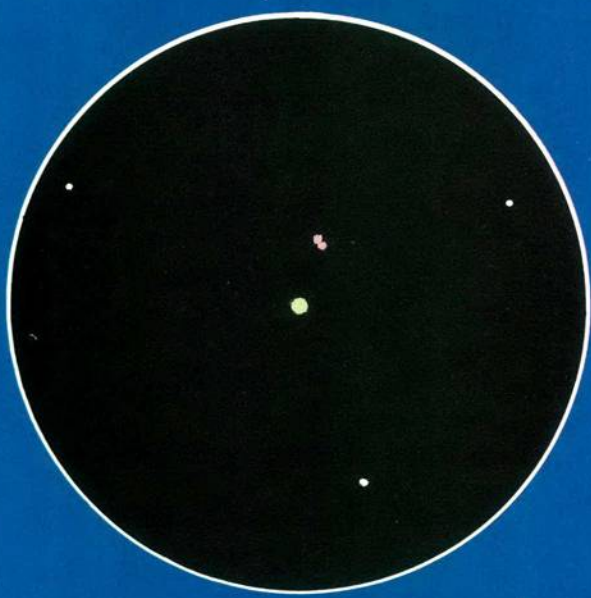
Zeta (ζ) Coronae Borealis

Just three degrees east of Mu Bootis is another fine stellar duo — fifth magnitude Zeta in the northern crown. Here, nearly matched bluish-white and greenish-white stars six seconds apart provide a real study in color for the observer.

Barns describes Zeta as a “vivid pair” without any reference to their actual hues. However, Webb mentions the combinations of greenish-white and green, and flushed white and blue-green on different nights. Although delicate, a six inch reflector makes these colors definite to a trained eye. Using your telescope, examine the images first in focus, then slightly out of focus, and finally with a two inch mask. You will find from actual observation which method of color perception is best suited for your eye and instrument.

R Coronae Borealis

Nestled within the northern crown, just above



Drawings by James Mullaney

the arc formed by the stars Epsilon, Delta and Gamma, lies an enigmatic variable star that should be on every observer's check list. This is the mysterious "disappearing star", R Coronae Borealis — first of its surprising type to be recognized.

William Tyler Olcott, one of the founders of the American Association of Variable Star Observers (AAVSO) and author of the classic **Field Book of the Skies**, called R "...a remarkable irregular variable star. It remains sometimes for years at 6.0 magnitude, just visible to the unaided eye, then declines in brightness rapidly within the course of a few weeks to 13th magnitude or lower, later slowly resuming its original brightness...."

R's exact location is nearly midway on a line from Alpha (α) to Iota (ι). It can be monitored with the unaided eye or binoculars for possible fading, but at least a 10 inch reflector is needed to follow its drop all the way to minimum. In smaller instruments, it simply vanishes like a dying ember at the telescope's magnitude limit — eventually reappearing again on its way back to maximum. During such fade-outs, the star's color changes from its usual dull yellow to a rather deep orange.

Should you suspect that R has started to fade, you should immediately inform the AAVSO at its headquarters (187 Concord Ave., Cambridge, Mass. 02138) so that word can be spread to its team of amateur and professional observers around the

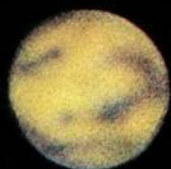
world. There is always the chance that you may be the first one to catch its disappearing act on the next performance!

Not far from R and just a degree south of Epsilon in the crown is another baffling star — this one an old recurring nova — whose behavior is the opposite of R's. Designated T Coronae Borealis, this object spends most of its time at minimum light near 11th magnitude. However, on at least two occasions (1866 and 1946), T has suddenly brightened to beyond second magnitude! As with its fellow actor R, a careful watch of the sky at its position may someday reveal another outburst.

A humorous story involving T is told by the famous variable star observer and comet hunter Leslie Peltier in his autobiography **Starlight Nights**. For more than 25 years, Peltier had kept watch on this star — but on that fateful night in February 1946, when it finally did brighten, he was asleep in bed! He ends the story by saying:

"I alone am to blame for being remiss in my duties; nevertheless, I still have the feeling that T could have shown more consideration. We had been friends for many years; on thousands of nights I had watched over it as it slept and then, it arose in my hour of weakness as I nodded at my post. I still am watching it but now it is with wary eye. There is no warmth between us any more." 

Planet Finder

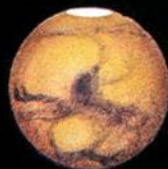


(A) Mercury

July 1
R.A. 5h11m
Dec. +19°24'
Mag. +0.9

(B) Mercury

July 15
R.A. 6h24m
Dec. +22°38'
Mag. -0.7



(M) Mars

July 1 15
R.A. 1h56m 2h33m
Dec. +10°08' +13°26'
Mag. +0.7 +0.6

July 1 15
R.A. 3h23m 3h42m
Dec. +12°18' +13°0'
Mag. +8.8 +8.8

(C) Cer

July 1 15
R.A. 3h23m 3h42m
Dec. +12°18' +13°0'
Mag. +8.8 +8.8



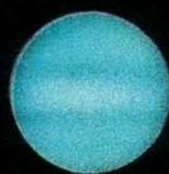
SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.



(S) Saturn

July 1 15
R.A. 7h29m 7h37m
Dec. +21°47' +21°31'
Mag. too near sun too near sun

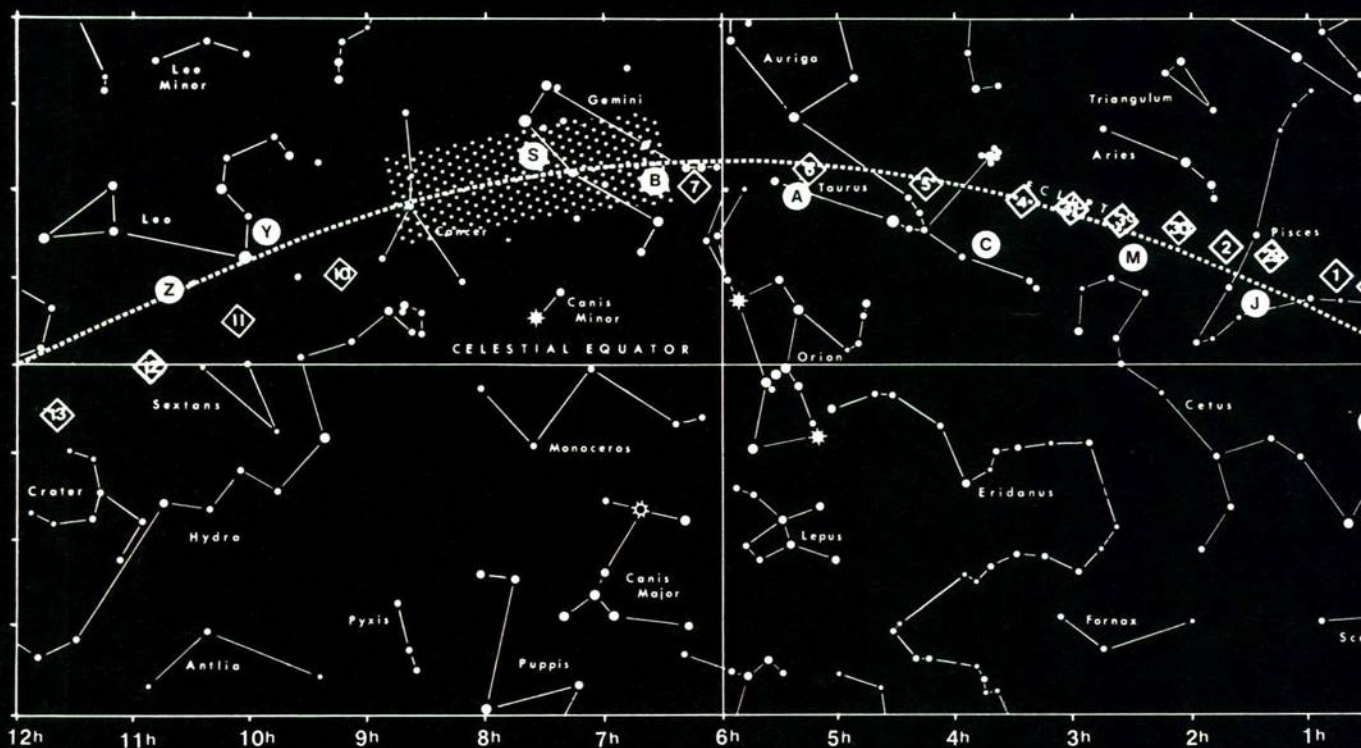


(U) Uranus

July 15
R.A. 13h46m
Dec. -10°24'
Mag. +5.7

July 15
R.A. 16h3
Dec. -20°1
Mag. +7.7

(N) Neptu



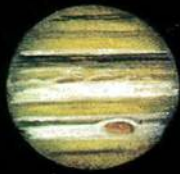
The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

July 1975



Vesta

July	1	15
R.A.	0h05m	0h16m
Dec.	-6°34'	-6°33'
Mag.	+7.2	+7.2



Jupiter

July	1	15
R.A.	1h22m	1h28m
Dec.	+7°17'	+7°48'
Mag.	-1.9	-2.0



Venus

July	1	
R.A.	9h47m	
Dec.	+14°18'	
Mag.	-4.1	

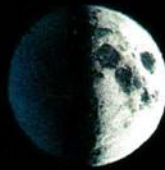
Venus

July	15	
R.A.	10h23m	
Dec.	+9°04'	
Mag.	-4.2	

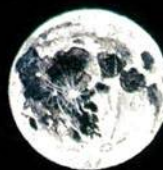


Pluto

July	15	
R.A.	12h50m	
Dec.	+12°47'	
Mag.	+14	



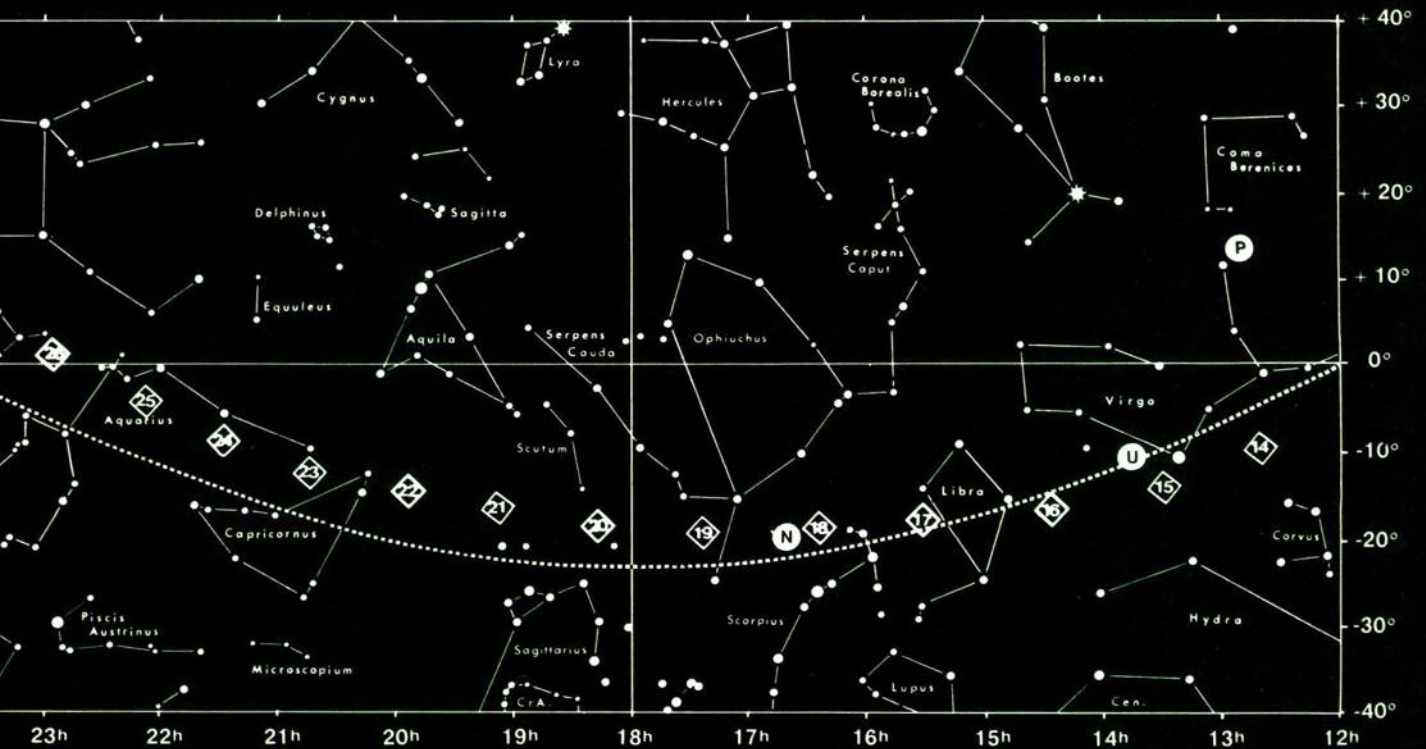
First Quarter
July 15



Full Moon
July 23



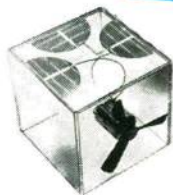
Last Quarter
July 31



measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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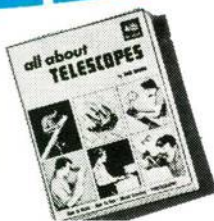
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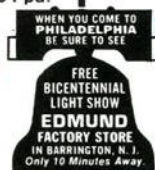


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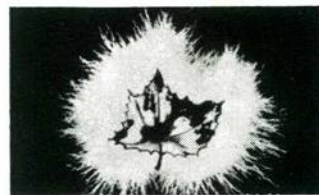
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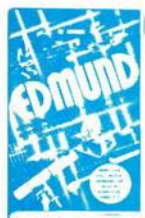
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